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Number 370646

Form 113c, W. D., S. G. O.
(Revised June 13, 1936)

G P O 3—10543

WAR DEPARTMENT TECHNICAL MANUAL

TM 8-285

This manual supersedes TM 8-285, 15 April 1944.

Army
U. S. Surgeon General's Office

TREATMENT OF CASUALTIES FROM CHEMICAL AGENTS

WAR DEPARTMENT • APRIL 1945

United States Government Printing Office
Washington: 1945

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WAR DEPARTMENT

Washington 25, D. C., 30 April 1945

TM 8–285, Treatment of Casualties from Chemical Agents, is published for the information and guidance of all concerned.

[AG 300.7 (7 Mar 45)]

BY ORDER OF THE SECRETARY OF WAR:

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Refer to FM 21–6 for explanation of distribution formula.

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This manual supersedes TM 8-285, 15 April 1944.

SECTION I

GENERAL

1. Introduction

a. Chemical warfare agents are used to produce casualties, to render food, water, and material unusable, to make terrain impassable or untenable, to provide concealment and to start fires.

b. The scope of chemical warfare is broad. It aims at groups rather than individuals. Gas can penetrate dugouts, emplacements and trenches. With the help of the airplane, chemical agents may produce casualties and destruction well back into the rear areas.

c. The purpose of this manual is to acquaint medical personnel with the treatment of casualties produced by chemical agents. Since medical units are themselves subject to chemical attacks, the medical officer must be familiar with the tactics of, and defense against, these attacks, as presented in FM 3–5 and 21–40.

2. Classification of Agents

Chemical warfare agents are classified accrding to their physiological action, persistency, and tactical use.

a. CLASSIFICATION BY PHYSIOLOGICAL ACTION. (1) Lung irritants (choking gases) primarily irritate and damage the respiratory tract (Example: phosgene).

(2) Vesicants (blister gases) injure the eyes, produce reddening and blistering of the skin, when inhaled damage the respiratory tract, and when absorbed cause systemic poisoning (Example: mustard).

(3) Lacrimators (tear gases) act primarily on the eyes, causing tears and intense, though temporary, pain (Example: chloracetophenone).

(4) Irritant smokes or sternutators (vomiting gases) irritate the nose, throat, and eyes. They may produce temporary prostration (Example: diphenylaminechlorarsine (adamsite)).

(5) Systemic poisins (blood and nerve poisons) stop essential physiological processes (Example: hydrocyanic acid).

b. CLASSIFICATION BY PERSISTENCY. The ability of an agent to

maintain an effective concentration under field conditions is called its persistency.

(1) Presistent agents are dangerous longer than 10 minutes, and may last for days or weeks. They are used to neutralize or force evacuation of certain areas (Example: mustard).

(2) Nonpersistent agents usually are dangerous less than 10 minutes. They do not render ground untenable after the cloud has passed (Example: phosgene).

c. CLASSIFICATION BY TACTICAL USE. (1) Casualty agents injure personnel (Example: mustard and phosgene).

(2) Harassing agents force the wearing of masks and thus impede operations (Example: irritant smokes).

(3) Screening agents produce obscuring smoke to prevent observation (Example: white phosphorus).

(4) Incendiaries ignite matériel and produce burns on personnel (Example: thermite).

3. Fundamentals of First Aid and Treatment

a. FIRST AID. (1) Immediate first aid following contamination with liquid blister gases is the all important factor in reducing the number of casualties since there are definite time limits after which first aid measures are useless. Decontamination combines both neutralization and removal of the agent before serious injury occurs. Unless incapacitated, each man will care for himself.

(2) If the soldier has been contaminated by liquid blister gas, as from an airplane spray or bomb burst, he will be confronted with the problem of carrying out several first aid or protective measures as rapidly as possible. With due regard to the practicability of carrying out these measures under the existing tactical situation, the following order of procedure is recommended:

(*a*) Apply first aid measures for eyes contaminated with liquid blister gas and follow by discontamination of the face. Hold breath until masked if at all possible.

(*b*) If wearing eyeshields, remove and discard. Discontaminate face and then apply gas mask. Hold breath until masked if at all possible.

(*c*) Remove or cut away clothing which is heavily contaminated with liquid blister gas.

(*d*) Decontaminate areas of skin which have been contaminated by liquid blister gas.

b. TREATMENT. Treatment designed to promote healing after injury has occurred, should be distinguished from first aid. Treatment is the function of the Medical Department.

SECTION II

LUNG IRRITANTS

4. General

a. The most important lung irritants are phosgene, chlorpicrin and chlorine. In general, the gases which are the most irritating, such as chlorine and chlorpicrin, are most likely to injure the trachea and bronchi, but also may cause pulmonary edema. Those which are less irritating such as phosgene, produce their major effect on the lungs and cause pulmonary edema. In addition to the above-designated lung irritants, vesicants, certain systemic poisons and incidental gases also damage the respiratory tract. (See secs. III, VIII, and IX.)

b. Troops exposed to a lung irritant gas need not be withdrawn during combat unless signs of pulmonary distress are apparent. The surgeon should so advise the responsible field commander.

c. Any service mask with M9A2 or later model canister the collective protector affords adequate protection.

5. Phosgene (CG)

a. PATHOLOGY. Aside from mild conjunctival irritation, the direct effects of exposures to phosgene gas are confined to the lungs. Changes in other organs are secondary to the pulmonary alterations and are relatively unimportant. The outstanding pathologic feature in the early stage is *massive pulmonary edema;* this results from the passage of fluid into the alveoli from capillaries whose permeability has been affected by the action of the agent. It is preceded by damage of the bronchiolar epithelium, the development of patchy areas of emphysema and partial atelectasis, and edema of the perivascular connective tissue. The epithelium of the trachea and larger bronchi is not significantly damaged. The lungs are large, edematous and darkly congested; edema fluid, usually frothy, pours from the bronchi and exudes from the sectioned lung tissue. *Hemoconcentration* results from the loss of plasma into the alveoli. The edema usually reaches a maximum 12 to 24 hours after gassing, and results in interference with the interchange of oxygen and waste products between the alveolar air and the capillary blood, so that in most instances of lethal exposure, death occurs within

the first 24 or 48 hours from the resulting *anoxemia*. With very high exposures, death may ensue in 5 hours, or possibly even less. In surviving individuals the edema begins to resorb after about 48 hours and, in the absence of complicating infection, recovery may take place with practically complete resolution of the lesion. Should this process be complicated by secondary bacterial infection of the lungs the clinical signs of a purulent bronchitis and bronchopneumonia will be apparent at about 3 to 5 days. In some cases there may be focal intrabronchial and peribronchial fibrosis as a result of the initial damage to the bronchiolar walls. Investigations have shown that in recovered individuals, the percentage of cases showing significant residual lesions is small. Such lesions as were found following gassing in the last war consisted chiefly of intances of chronic emphysema, chronic bronchitis or bronchiectasis, and pulmonary fibrosis.

b. SYMPTOMS. Immediately after exposure there is likely to be coughing, choking, a feeling of tightness in the chest, nausea and occasionally vomiting, headache and lacrimation. The presence or absence of these systems is of little value in immediate prognosis, as some patients with severe cough fail to develop serious lung injury, while others with no signs of early respiratory tract irritation go on to fatal pulmonary edema. There may be slowing of the pulse initially, followed usually by an increase in rate. A period follows during which abnormal chest signs are absent and the patient may be symptom-free. This interval commonly lasts 2 to 24 hours, but occasionally is shorter. It is terminated by the signs and symptoms of pulmonary edema. These begin with rapid, shallow breathing, painful cough and *cyanosis*. Nausea and vomiting may appear. As the edema progresses, discomfort, apprehension, and dyspnea increase and much frothy sputum is raised. Rales and rhonchi are audible over the chest, and breath sounds are diminished. The patient may develop a shocklike state, with leaden, clammy skin, low blood pressure, and a feeble heart.

c. DIAGNOSIS. Irritation of the nose and throat by phosgene may be mistaken for an upper respiratory tract infection. Difficulty in breathing and complaint of tightness in the chest may suggest an acute asthmatic attack. The pulmonary edema is like that produced by many other gases and may be confused with the edema associated with heart failure. Diagnosis can be established with certainty only from a definite history of exposure to phosgene.

d. TREATMENT. (1) *Rest*. Pending the appearance of definite symptoms, men may continue their duties. When symptoms of respiratory distress appear, the patient should be evacuated by litter.

(2) *Warmth.* Phosgene casualties should be kept only comfortably warm.

(3) *Oxygen therapy.* Anoxia should be treated with oxygen. The need for oxygen is indicated by cough, dyspnea, cyanosis and restlessness. Oxygen should be administered in as high a concentration as possible, in any case high enough to eliminate cyanosis. Oxygen decrease anoxia and quiets the patient. It is best administered by mask. Lower and less well controlled concentrations are obtainable in tents and with nasal catheters. Carbon dioxide-oxygen mixtures are not indicated in phosgene poisoning.

(4) *Venesection.* There is at present no definite evidence that venesection is beneficial at any time; it is certainly harmful during the shock-like state.

(5) *Sedation.* If cough is a prominent symptom, codeine in doses of 0.032 to 0.064 grams (grains ½ to 1) is effective. If oxygen fails to quiet the patient, morphine may be used subcutaneously in a dose of 0.01 to 0.015 grams (grains 1/6 to 1/4). The physician must weigh the value of its sedative effect against its depression of respiration. Sedative doses of barbiturates are ineffective and large doses may be harmful.

(6) *Specific antibasterial therapy.* (*a*) Specific antibacterial therapy should not be given during the latent period. Thereafter, it may be administered for the prevention of pulmonary infection as soon as the edema begins to subside, as evidenced by an improvement in the patient's general condition. Decision as to the prophylactic use of specific therapy following exposure to lung irritants will be dependent in part upon the estimated severity of the lung damage and in part upon the season of the year, the locality, and the prevalence of respiratory infections. The drug of choice is penicillin which, when available in adequate amounts, will be used in all cases of this type in which specific therapy is considered desirable. A suggested dosage schedule is 15,000 Oxford units intramuscularly every 3 hours for a minimum of 4 days, making a minimum total dose of 480,000 Oxford units. Prolongation of the treatment will be determined by clinical evaluation of the individual patient.

(*b*) If penicillin is not available, sulfadiazine will be used when specific antibacterial therapy is deemed desirable. Like penicillin, sulfadiazine will be used only when the severity of the lung damage, or other considerations indicate the probability of development of pulmonary infection if specific therapy is withheld. When sulfadiazine is used, it should be prescribed in adequate dosage. A sug-

gested schedule is 4 grams (grains 60) as an initial dose, and 1 gram (grains 15) every 4 hours therafter for a minimum of 4 days, but longer when necessary. The usual precautions to prevent the complications of sulfonamide therapy must be observed. The daily urine output must be maintained above 1500 cc. and the urine should be kept alkaline by the administration of sodium bicarbonate (4 grams with the initial dose of sulfadiazine and 2 grams every 4 hours thereafter). Alertness must be maintained to detect any signs of drug toxicity through repeated blood counts, urinalyses, and inspections of the patient for signs of a skin rash. Evaluation of a low grade fever in these patients is difficult since the fever may be caused by absorption of the break-down products of necrotic tissue, infection, or drug reaction.

(*c*) If pulmonary infection appears, as evidenced by an increase of the body temperature or change of chest signs, penicillin or sulfonamides must be used in the dosage outlined in (*a*) and (*b*) above.

(7) *Expectorants.* Expectorants should not be used in the treatment of phosgene poisoning.

(8) *Other measures.* Atropine does not diminish edema or improve breathing; its acceleratory action on the heart is undesirable. Plasma is of no value in the treatment of phosgene poisoning. Infusions pass readily into the lungs and increase the edema. Concentrated plasma is even more harmful. Surgery, except emergency measures to save life, is contraindicated in the active stage of edema. If anesthesia is required, local infiltration or nerve block is the method of choice. Cardiac and respiratory stimulants, such as adrenalin, ephedrine, benzedrine, coramine, and metrazol, do more harm than good. Alcohol is contraindicated.

e. Convalescent Care. Absolute rest must be continued until the acute symptoms have disappeared. As recovery progresses, exercise should be resumed gradually. Sitting in bed should be permitted first, then for brief intervals in a chair. Bathroom privileges should follow and then short periods of alternate walking and resting. Later the convalescent should walk increasing distances.

f. Prognosis. Prognosis should be guarded because of the insidious nature of the poisoning. Most deaths occur within the first 48 hours. The few which occur later are due largely to bronchopneumonia. Casualties from phosgene which survive more than 48 hours usually recover without sequelae. Rarely do chronic bronchitis and bronchiectasis result. The incidence of tuberculosis is

not greater in those poisoned by phosgene than in the general population.

6. Chlorpicrin (PS)

a. PATHOLOGY. As a rule, chlorpicrin has been used in warfare in combination with other agents. When used alone, its effects on the lung are quite similar to those of phosgene. Apart from the difference in toxicity, chlorpicrin may produce almost as severe pulmonary edema as phosgene. There may be even more severe necrosis of the bronchiolar epithelium than is produced by phosgene, and, in addition, focal necrosis of the epithelium of the trachea and large bronchi, although in this respect the action of chlorpicrin is much less marked than that of chlorine. The course of events following the inhalation of chlorpicrin is essentially the same as that following phosgene. Chlorpicrin vapor irritates the conjunctiva, and severe exposures may result in corneal injury. It is also irritating to the skin, and contamination of the skin with liquid chlorpicrin may result in deep burns.

b. SYMPTOMS. Irritation of the eyes is the first symptom noted, as chlorpicrin is a strong lacrimator. This is frequently followed by pain in the chest, cough, nausea and vomiting. Severe exposure causes pulmonary edema, like that produced by phosgene, and generalized muscular weakness, with feeble heart action. Repeated small exposures increase susceptibility to asthmatic attacks from traces of this gas.

c. DIAGNOSIS. Diagnosis can be established by a history of exposure, a characteristic flypaper odor on clothing, and the symptoms described in *b* above.

d. TREATMENT. Irritation of the eyes and nose can be relieved by irrigation with water, followed by the instillation of eye and nose drops (Medical Department item No. 9109100). Inhalation of steam relieves the bronchial irritation. Codeine helps to allay the cough. If pulmonary edema develops, it is treated like that caused by phosgene.

e. PROGNOSIS. Most deaths occur in the first 24 hours and if later are usually due to bronchopneumonia. Casualties surviving this period generally recover without sequelae.

7. Chlorine (CF)

Chlorine is very irritating to the respiratory tract. It produces damage which may result in necrosis of the mucous membrane of the trachea, bronchi, and lungs. Pulmonary edema occurs, similar

to that caused by phosgene. After exposure, the initial symptoms are: burning in the throat, violent coughing, a feeling of suffocation, nausea and occasionally vomiting. Pulmonary edema follows sometimes within 20 minutes. The history and the intense irritation of the nose and throat are aids to early diagnosis. The treatment of chlorine poisoning is the same as that outlined for chlorpicrin. (See par. 6*d*.)

SECTION III

VESICANTS

8. General

a. The vesicants act primarily on the eyes and skin. In addition, they damage the respiratory tract when inhaled and, when absorbed, they cause systemic poisoning. The nitrogen mustards and the arsenical vesicants are the most dangerous in this last respect.

b. Vesicants poison food and water and render other supplies dangerous to handle.

c. Casualties contaminated with vesicants endanger unprotected attendants. Those in contact with such patients should wear, at least, protective masks, impermeable aprons and gloves, and other protective clothing if the area is contaminated.

d. Special precautions must be taken in receiving contaminated casualties to prevent injury of others. These casualties should be undressed in the open to prevent vapor accumulation indoors. They should be kept separate from contaminated patients until decontamination is complete. Contaminated litters, blankets, and equipment should be left outdoors. It is necessary to decontaminate equipment and ambulances after transporting such casualties. (See par. 146*d*, FM 21–40.)

e. Identification of the agent is important in order to apply specific treatment.

f. Any service mask protects only the face, eyes and respiratory tract. The eyeshield protects the eyes from contamination by liquid, but not from vapor. Permeable protective clothing and protective ointment help to prevent the vesicant from reaching the skin.

9. Mustard (H)

a. PROPERTIES. Mustard is an oily liquid heavier than water. It ranges from colorless when pure to dark brown when plant-run. Its oder is like garlic or horseradish. It is only slightly soluble in water, which gradually destroys it, but undissolved mustard may persist in water for long periods. It is more soluble in fats and oils, and freely soluble in gasoline, kerosene, acetone, carbon tetrachloride, and alcohol. These solvents do not destroy mustard. From

contaminated ground or materials mustard disappears through evaporation or through hydrolysis. It can be destroyed rapidly by decontaminating chemicals or by boiling in water. It is slowly absorbed by rubber articles and so may contaminate their inner surfaces. The persistence of hazard from mustard vapor or liquid depends on the degree of contamination by the liquid, the type of mustard, the nature of the terrain and of the soil, the type of munition used to disperse the mustard and the weather conditions. The persistence of mustard in wooded area may be much longer than in the open. In winter, mustard persists two to five times as long as in summer and the hazard from the vapor is many times greater under hot than under cool conditions. Concentrations of mustard vapor should be estimated in the field by gas detectors. (See par. 127, FM 21–40, and pars. 85–90, TM 3–290.)

b. EYE. (1) *Pathology, symptoms, and prognosis.* (*a*) The eye is more vulnerable to mustard than either the respiratory tract or the skin. Eye lesions follow an exposure of 2 hours to a concentration barely perceptible by odor (0.001 mg. per liter). This exposure does not significantly affect the respiratory tract or skin.

(*b*) A latent period of 4 to 12 hours follows mild exposure, after which there is lacrimation and sensation of grit in the eyes. The conjunctivae and lids become red and edematous. Heavy exposure irritates the eye after a shorter latent period, and produces more severe lesions. Mustard burns of the eye may be divided into groups.

1. Mild conjunctivitis (75 percent of cases in World War I). Recovery, 1 to 2 weeks.

2. Severe conjunctivitis with minimal corneal involvement (15 percent of cases). Blepharospasm, and edema of lids and conjunctivae. Orange-peel roughening of the cornea. Recovery, 2 to 6 weeks.

3. Mild corneal involvement (10 percent of cases). Areas of corneal erosion staining green with fluorescein. Superficial corneal scarring and vascularization. Iritis. Temporary relapses. Convalescence, 2 to 3 months. This group requires hospital care.

4. Severe corneal involvement (approximately 0.1 percent of cases). Ischemic necrosis of conjunctivae. Dense corneal opacification with deep ulceration and vascularization. Convalescence, several months. Predisposition to late relapses.

(2) *Decontamination of the eyes.* (*a*) *Vapor.* When the eyes are exposed to mustard vapor alone, no decontamination procedure

is of any value. The gas mask should be put on immediately.

(*b*) *Liquid.*

1. *All* contaminations of the eyes by *any* liquid blister gas whether they be by mustard, nitrogen mustards, lewisite or mixtures thereof are decontaminated by *one standard procedure.* The decontamination incorporates the use of BAL Eye Ointment (or BAL Ointment), massage and irrigation. Immediately after the eye has been contaminated by a liquid blister gas BAL Eye Ointment is squeezed directly into the lower conjunctival sac. In cases where the eye cannot be opened (for example, after contamination by lewisite) the ointment should be applied to the lids and rubbed well. This will work sufficient ointment between the lids to relieve pain and blepharospasm to such an extent as to make it possible for the soldier to open the eye thus permitting him to instil larger quantities of the ointment into the lower sac. The lids are then closed and massaged for 1 minute. This is followed by irrigation of the eye with water from the canteen or other available uncontaminated source. To accomplish this the head is thrown back, the lids are forced open with one hand, while the water is poured into the eye from a container in the other hand. The water should be poured directly and slowly into the eye and should be continued *for at least 30 seconds,* or until the canteen is empty, and not longer than 2 minutes. If BAL Eye Ointment or BAL Ointment is not immediately available, the eye should be irrigated as early as possible without waiting to obtain the ointment. The decontamination must be completed before the gas mask is put on, in spite of the presence of vapor. Therefore, the individual should hold his breath as much as possible until the treatment is completed and the gas mask can be adjusted. *In contaminations by liquid mustard the initiation of the first aid within the first few seconds is markedly effective and after 2 minutes is of very little value.* (*Note.* The fact that the individual tubes of BAL Eye Ointment or BAL Ointment do not have printed on them directions for use against mustard, nitrogen mustards, and mixtures of these with lewisite is not to be considered a contraindication to its use against these agents.)

2. Liquid mustard in the eye causes no immediate pain or

discomfort. When BAL Eye Ointment is placed into an eye contaminated with this agent there will be immediate irritation and blepharospasm. *This is to be expected and the first aid procedure should not be discontinued because of it.* The irritation from the ointment stops as soon as the irrigation is begun. However, the irrigation should not be stopped as soon as the stinging disappears, but should be continued for the length of time outlined in paragraph (b) 1 above.

3. BAL Eye Ointment or BAL Ointment placed in an uncontaminated eye is quite irritating and causes immediate stinging and blepharospasm which may interfere with the individual's combat ability for a period up to 15 minutes. Therefore, the ointments should be used in the eye only when the individual is fairly certain that his eye has been contaminated by liquid blister gas. The chance of liquid contamination is slight except when in the close vicinity of a shell or bomb burst, or in a direct airplane spray.

4. Previous manuals have stated that irrigation alone should be used as first aid for liquid mustard contamination of the eye. Recent studies have shown that BAL Eye Ointment followed by irrigation is superior to irrigation alone. A further advantage of this new first aid procedure is that since it is used for *all* liquid blister gas contaminations of the eye, the soldier has to remember only *one* first aid procedure. He is therefore not required to distinguish between different contaminating agents at a time when this would be difficult. Therefore, previous directives are to be disregarded in favor of the method described above.

(3) *Decontamination of eyelashes and lids.* The lids, lashes, and skin areas close to the eyes are best decontaminated by washing with soap and water. Protective ointment is irritating to the eyes. If water is not available, liquid vesicants may be removed from the lids by dabbing carefully with a cloth or other absorbent.

(4) *Treatment of mustard conjunctivitis.* (*a*) Mild lesions require little treatment. Although they seldom become infected, 3 percent sodium sulamyd solution, two drops instilled every 4 to 8 hours, (Medical Department item No. 9120300) has an analgesic action and aids in preventing sepsis. Two drops of eye and nose drops (Medical Department item No. 9109100) may be instilled for added comfort. If the lids tend to stick together during sleep,

petrolatum (Medical Department item No. 9116500) may be applied to the lid margins.

(*b*) More severe injuries will cause enough edema of the lids, photophobia, and blepharospasm to obstruct vision. This is very alarming to the patient; consequently, the lids should be gently forced open to assure the patient that he is not blind. Pain may be allayed temporarily by eye and nose drops (Med. Dept. item No. 9109100), but these drops, or other local anesthetics, should not be used persistently. It is best to control the pain by morphine and other systemic sedation. All patients having severe photophobia and blepharospasm should have 1 drop atropine solution 1 percent instilled or an atropine ophthalmic disc (Med. Dept. item No. 9116300) inserted into the eye three times a day. To prevent infection, a few drops of 3 percent to 10 percent solution of sodium sulamyd should be instilled every 4 hours. Penicillin sodium solution 1000 units per cc. or sulfathiazol ophthalmic ointment (Med. Dept. item No. 1464000) may be substituted for sodium sulamyd. The eye must not be bandaged or the lids allowed to stick together. Sealing of the lids may be prevented by the application of petrolatum to the lid margins. The accumulation of secretions in the conjunctival sac, or pressure on the eye, predisposes to corneal ulceration. Irrigations should be gentle and must be held to the minimum necessary to remove secretions. Copious irrigation should be avoided as it tends to loosen and remove injured corneal epithelium. Isotonic or slightly hypertonic sterile solutions must be used, never hypotonic solutions; 1 percent saline is satisfactory. When the lids can be opened sufficiently for an ophthalmic examination, the cornea should be stained with fluorescein, one drop of 2 percent solution in saline, or by insertion of fluorescein ophthalmic disc (Med. Dept. item No. 9116300) into the lower conjunctival sac. The eyes should then be rinsed with a few drops of sterile saline and examined for yellowish-green staining of the cornea. Staining indicates damage to, or loss of, epithelium. If the cornea stains, or if severe photophobia persists, the patient should be transferred to the care of the ophthalmologist. When possible the patient should be kept in a darkened room. Dark glasses or an eyeshade may be worn for photophobia, but should be discarded as soon as possible to prevent psychologic sequellae.

(5) *Treatment of infected mustard burns of eye.* Secondary infection is a serious complication and increases the amount of permanent scarring of the cornea. If infection develops, the eye should be treated with several drops of a 10 percent solution of sodium sulamyd every 2 hours, or penicillin sodium, 1000 units per cc., every 4 hours, or sulfathiazol ophthalmic ointment every 4 hours.

Irrigation should ge gentle and employed only to remove accumulated exudate (4) (*b*) above. Pain is controlled as described in (4) (*b*) above. Patients with secondary infection or other complications should be referred to the ophthalmologist.

c. SKIN. (1) *Pathology.* The severity of the lesions and the rapidity with which they develop are greatly influenced by weather conditions as well as by the degree of the exposure. Hot, humid weather strikingly increases the action of mustard. Even under temperate conditions, the warm, moist skin of the perineum, external genitalia, axillae, antecubital fossae, and neck are particularly susceptible.

(*a*) *Latent period.* After exposure, there is a latent period which varies with the degree of exposure. It may be as short as an hour with liquid contamination when the weather is hot and humid, or as long as several days with mild vapor exposures. With most vapor exposures in temperate weather, the latent period usually lasts 6 to 12 hours.

(*b*) *Erythema.* Erythema gradually appears and becomes brighter, resembling sunburn. Microscopically, there is capillary hyperemia in the corium, accompanied by a variable degree of dermal edema. If severe burns the latter may be considerable, and limit motion of a limb.

(*c*) *Vesication.* Except with mild vapor burns, erythema is followed by vesication. This is caused by progressive development of liquefaction necrosis of cells in the lower layers of the epidermis. Exudation of tissue fluid into the spaces so formed results in an intraepidermal vesicle. Clinically, multiple pinpoint lesions may be seen to arise within the erythematous skin; these enlarge and coalesce to form the typical blister which is usually large, domed, thin-walled, superficial, translucent, yellowish, and surrounded by erythema. The blister fluid is clear, at first thin and straw-colored, later yellowish and tending to coagulate. It is completely nonirritating. Liquid contamination of the skin usually results in a ring of vesicles surrounding a gray-white area of skin which, though necrotic, does not vesicate.

(*d*) *Resorption.* If the blister does not rupture, resorption takes place in about a week. The roof forms a crust, beneath which reepidermization takes place. However, because of their thinness and tenseness, the blisters are fragile and usually break. If the roof becomes ragged, the burn may be considered an open wound. Such lesions may become secondarily infected.

(*e*) *Healing.* Since the damage to the corium is relatively superficial except in severe burns, healing takes place with little or no scare tissue formation except in very severe or infected burns.

(*f*) *Pigmentation.* Mustard burns usually are followed by a

persistent brown pigmentation, except as the site of actual vesication, where there may be a temporary depigmentation.

(*g*) *Hypersensitivity.* Repeated burns may lead to hypersensitivity of the skin to mustard.

(2) *Symptoms* and prognosis. (a) An outstanding characteristic of the action of mustard is its *insidiousness.* Exposures to mustard are accompanied by no symptoms, nor do any local manifestations occur until the development of erythema when there may be itching and mild burning. This pruritus may last for a number of days and even after healing. The blisters may be painful.

(*b*) Very mild mustard burns heal within a few days. Burns of moderate severity heal usually within 2 to 4 weeks. Severe or infected burns may require 6 to 8 weeks or even longer to heal.

(3) *Diagnosis of skin lesions due to mustard.* Similar skin burns are produced by mustard and the nitrogen mustards. Mustard burns are also similar in appearance to those due to lewisite and other arsenical vesicants. Differentiation of mustard lesions from those produced by lewisite is based upon: history of exposure to mustard; absence of pain or discomfort at time of contamination (lewisite is irritating or painful immediately); and wide zone of erythema surrounding blisters (lewisite, not prominent). It should be remembered that vesicular lesions, much like mild mustard burns, may be produced in sensitive individuals by a variety of substances, notably plant poisons such as poison ivy or poison oak.

(4) *Treatment of mustard erythema.* Mustard erythema in mild cases requires no treatment. If annoying itching is present, considerable relief can be obtained with calamine lotion (containing 1 percent each of phenol and methol, Medical Department item No. 9104800). Severe erythema is often accompanied by edema, stiffness and pain. Painful erythema of the genitalia may be treated with calamine lotion and a suspensory bandage. Alternatively petrolatum, a light protective dressing and suspensory may be used.

(5) *Treatment of mustard blister.* (*a*) Blisters should be treated by application of sterile petrolatum (or boric acid ointment) dressings. Frequent changes of dressing are undesirable. The dressing should be left in place as long as possible (up to 2 weeks). Small blisters of the face are best left alone. Large blisters may be covered with a sterile perolatum dressing. Burns of the genitalia may be treated with a sterile petrolatum dressing and suspensory, using a minimum of petrolatum to avoid undue moisture with resulting excoriation.

(*b*) If the dressing sticks to the wound, care will be necessary to avoid pulling off the blister top. It is good practice to trim the

edges of the adherent gauze, leave it in place, and put a fresh dressing over it. If necessary to examine the wound, the dressing can be soaked off.

(6) *Treatment of denuded areas.* (*a*) The same sterile technique as for thermal burns, including face masks, should be employed. Frequent change of dressing is to be avoided.

(*b*) Blistered areas which have become denuded may be treated with sterile petrolatum or boric acid ointment as for thermal burns (app. V).

(*c*) Strong antiseptics and escharotics of all kinds are contraindicated.

(*d*) Other phases of the late treatment are similar to those of the treatment of thermal burns. Thus, occasional extensive granulating surfaces may require skin grafting. Multiple pinch grafts have proved successful.

(7) *Treatment of infected mustard burns.* (a) Contamination of mustard burns with saprophytic bacteria is common, but not serious. If there is no inflammatory reaction, the treatment is the same as for uncontaminated burns (5) and (6) above.

(*b*) Infected burns showing inflammatory reaction should be considered infected wounds. They may be treated locally by the use of sterile petrolatum or boric acid ointment with proper cleansing and drainage, or hot sterile saline dressings.

(*c*) Strong local antiseptics and escharotics are contraindicated.

(8) *Specific anti-bacterial therapy.* When indicated, specific antibacterial therapy should be instituted. Penicillin is the drug of choice and should be given intramuscularly in doses of 25,000 units every 3 hours as long as indicated. For cases in which sulfadiazine is used, it should be given orally with an initial dose of 4 grams (grains 60), and 1 gram (grains 15) every 4 hours thereafter. Sufficient fluids should be given to maintain the output of urine over 1500 cc. (1½ qts.) daily. Four grams (grains 60) of sodium bicarbonate should be given with the initial dose of sulfadiazine and 2 grams (grains 30) every 4 hours thereafter to keep the urine alkaline.

(9) *Decontamination of skin.* (*a*) Personal decontamination is an individual responsibility of all ranks in all branches. Only casualties who are unable to decontaminate themselves are cared for by the Medical Service.

(*b*) Personal decontamination is the removal of liquid mustard at the earliest possible instant. The importance of prompt action cannot be overstressed. Proper skin decontamination during the first minute is always successful. After 3 minutes on the hot sweaty skin, or 5 minutes on the cool dry skin, no method of decontamination will prevent blistering. Decontamination should be per-

formed, however, no matter how late, as long as liquid mustard is still present. Decontamination is of no value after vapor exposure.

(*c*) Ointment, Protective, M5 will protect against liquid blister gas for a short time. Areas of skin contaminated with liquid blister gas, whether protected by the ointment, or unprotected must be decontaminated as soon as possible. The free liquid blister gas is blotted from the skin with the absorbent cloth wrapped around each tube of ointment or by using any absorbent material at hand. Discard the used absorbent. Ointment is then applied freely to the area, the excess removed, more ointment reapplied and allowed to remain. If contamination with blister gas is light, no blotting is necessary but generous application of Ointment, Protective, M5, with thorough rubbing will be sufficient.

(*d*) If reddening of the skin has appeared, cleanse the area with soap and water. Protective ointment is irritating to the reddened skin and should be used only when liquid mustard is still present and soap and water are not available for thorough washing. Solvents should not be used if soap and water are available.

(*e*) Should the supply of protective ointment run short, the following alternatives may be employed:

1. *Bleach paste.* Prepared by mixing one part bleach and two part of water. Because of its irritant properties, it must be washed off the skin within 3 minutes.
2. *Solvents.* Any nonirritant organic solvent may be used in an emergency to dissolve and dilute the liquid mustard. Since solvents do not neutralize the vesicant, the mustard solution formed must be completely and rapidly removed from the skin by flooding with a large excess of the solvent. Alternatively, the area may be sponged repeatedly with cotton or gauze dampened with solvent, with care to avoid the spread of mustard from contaminated skin. Gasoline, kerosene, alcohol, carbon tetrachloride (from automobile fire extinguishers) are most commonly available. (***Caution:*** Precautions against fire and explosion must be observed when employing inflammable solvents.)

(*f*) The decontaminated skin areas should be thoroughly washed with soap and water as soon as practicable after decontamination.

(*g*) Wounded cases, with liquid mustard contamination of the skin, will seldom be received at field installations in time to prevent subsequent blistering. Nevertheless, if erythema has not appeared, known or likely areas of contamination should be decontaminated as outlined above.

(10) *Decontamination of hair.* The contaminated hair may be clipped off, or decontaminated with bleach paste. The scalp should

then be washed with soap and water. Protective ointment may be used, but is difficult to apply and to remove.

d. RESPIRATORY TRACT. (1) *Pathology.* (*a*) Inhalation of mustard vapor causes damage primarily to the laryngeal and tracheobronchial mucosa, which develops slowly after the exposure. Minimal amounts of vapor may be inhaled without significant damage. More severe exposures result in hyperemia or the respiratory mucous membrane, and necrosis of the lining epithelium. With severe exposures, the necrotizing action is accompanied by exudation which results in a diphtheritic-like pseudomembrane which may form a cast of the tracheobronchial tree.

(*b*) In the more severe cases, the pulmonary parenchyma shows congestion, mild patchy edema, moderate acute emphysema, and focal atelectasis. Altogether, these changes are insufficient to cause anoxia, but they are frequently complicated by bacterial infection of the lung which results in suppurative bronchitis and bronchopneumonia. The latter is responsible for almost all deaths following *vapor* exposures. The mortality from mustard in the American Expeditionary Force, slightly more than 2 percent, was almost entirely from such complication following inhalation of vapor.

(2) *Symptoms and prognosis.* Respiratory tract lesions, like skin injuries, develop slowly and do not reach maximal severity for several days. Symptoms begin with hoarseness, which may progress to aphonia. A cough appears early and becomes productive. Fever, dyspnea, and moist rales may develop. The incidence of bronchopneumonia is high. Convalescence is slow, and cough may persist a month or longer. Milder symptoms, like hoarseness, last only a week or two.

(3) *Treatment of respiratory tract injury due to mustard.* Mild respiratory tract injury, with hoarseness and sore throat only, usually requires no treatment. Cough may be relieved by codeine, and pharyngitis with alkaline gargles. Relief from nasal irritation may be obtained with the eye and nose drops (Medical Department item No. 9109100). Since severe respiratory tract injuries predispose to bronchopneumonia, when clinical exidence of such injury becomes manifest, the prophylactic intramuscular administration of penicillin or oral administration of sulfadiazine is indicated (par. 5*d*(6)). Laryngitis and tracheitis should be treated with steam inhalations. Morphine or the barbiturates can be used to quiet the patient. Secondary bronchopneumonia should be treated like any other bronchopneumonia.

e. SYSTEMIC AND GASTRO-INTESTINAL. (1) *Symptoms.* (*a*) Ingestion of food or water contaminated by liquid mustard produces nausea and vomiting, pain, diarrhea and prostration. Mustard vapor does not significantly contaminate food or water.

(*b*) Exposure of the skin alone to mustard may cause systemic symptoms such as malaise, nausea, vomiting and feverishness, coming on at about the time of onset of the erythema. With severe exposures, particularly extensive liquid contamination of the skin, these symptoms may be so marked as to result in prostration. Exceptional cases of severe systemic mustard poisoning may also present central nervous symptoms such as cerebral depression, and paraympathomimetic effects such as bradycardia and cardiac irregularities. Cerebral excitation and salivation have been observed in animals, as well as bloody diarrhea and excessive loss of fluid and electrolytes. Hemoconcentration and shock may occur. It must be emphasized that such severe systemic effects do not occur with ordinary mustard exposures.

(2) *Pathology.* With ordinary skin or respiratory exposures to mustard, no apparent systemic lesions develop. With amounts approaching a lethal dose, injury to the hematopoietic tissues (bone marrow, lymph nodes and spleen) may result. Such hematopoietic damage is reflected in the peripheral blood by leucopenia and thrombocytopenia.

(3) *Treatment.* (*a*) In the treatment of the systemic symptoms, atropine (Medical Department item No. 1086000) subcutaneously (0.6 mg. (grains 1/100)) may prove useful in reducing the gastro-intestinal activity. The general discomfort and restlessness may require large doses of sedatives, for which the barbiturates and morphine may be indicated. In the exceptional cases of severe systemic poisoning with vomiting and diarrhea, leucopenia, hemoconcentration, and shock, every effort should be made to maintain an adequate nutritional status and replace the loss of fluid and electrolytes by transfusions of whole blood or plasma, and infusions of glucose and saline. Paregoric and bismuth subcarbonate can be used for relief of diarrhea.

(*b*) Injury due to the ingestion of liquid mustard in food or water may require morphine and atrophine for relief of pain, and shock therapy for collapse.

(4) *Prognosis.* (*a*) With ordinary field exposures of mustard vapor, it is not anticipated that deaths will occur from the systemic effects of the absorbed mustard. Such deaths may occur from prolonged exposures to high concentrations of vapor, or in instances of extensive liquid contamination of the skin in which decontamination is neglected or unduly delayed. The occurrence of shock or pronounced leucopenia in such cases may be regarded as bad prognostic signs.

(*b*) Severe injury from ingestion of mustard is rare.

10. Nitrogen Mustards (HN)

a. GENERAL. The nitrogen mustards are oily, colorless, or pale yellow liquids, sparingly soluble in water but freely soluble in organic solvents. Some possess a faint, fishy odor, while others are odorless. Their volatility varies with the particular compound. All are persistent, though not equally so. They are less readily hydrolyzed than mustard or lewisite. All their hydrolytic products, except the final ones, are toxic.

b. EYES. (1) *Symptoms and pathology.* Nitrogen mustards irritate the eye in doses which do not significantly damage the skin or respiratory tract. The irritation (caused by the nitrogen mustards) appears in a shorter time than that from mustard but not so early as that from lewisite. Mild or moderate exposure causes mild smarting and lacrimation within 20 minutes. Thereafter symptoms may wax and wane until they become persistent about 2½ hours later and reach their maximum in 8 to 10 hours. After more severe exposure, symptoms may begin immediately and progress for 24 hours or longer. Mild exposure produces erythema and edema of the palpebral and bulbar conjunctivae and superficial steamy haziness of the cornea. Irritation, lacrimation, deep eye pain, miosis, and photophobia are usually present. After more severe exposure the symptoms described above are followed by spotty hemorrhagiv discolorations of the iris. The corneal epithelium begins to show a roughened, lusterless surface, with areas of punctate staining demonstrable by the instillation of fluorescein (Medical Department item No. 9116300). Severe exposure may cause the corneal epithelium to exfoliate. Slit lamp examinations will reveal clouding and edema of the corneal substance extending deep below Bowman's membrane. Local necrosis of the cornea may rupture the globe.

(2) *Decontamination and treatment.* These are the same as for mustard (par. 9*b*). In general the symptoms and lesions are more severe, requiring intensive and early treatment with atropine (Medical Department item No. 9116300).

(3) *Prognosis.* The prognosis in contamination with any liquid nitrogen mustard is serious, unless the agent is removed by immediate decontamination. Mild injury progresses to complete recovery in about 2 weeks. Severe injury heals more slowly, requiring 9 to 12 weeks or longer. The cornea heals by vascularization, and the iris with discoloration and atrophy. Scarring may be expected.

c. SKIN. (1) *Symptoms and pathology.* In mild exposures there may be no skin lesions. After severe exposure, erythema may appear earlier than in mustard contamination. There may be irritation and itching as with mustard. Later, blisters may appear in the erythematous areas. Liquid nitrogen mustards are also

vesicant. The skin lesions are similar to those caused by mustard.

(2) *Decontamination and treatment.* The absorption of liquid nitrogen mustards through the skin is slower and more complete than that of mustard. Therefore, for the prevention of systemic toxicity, decontamination should be carried out as late as 2 to 3 hours after exposure, even at the expense of increasing somewhat the severity of the local reaction. Early decontamination procedures are the same as for mustard. (See par. 9*c* (9.)). If early decontamination has been neglected late decontamination should be performed even if erythema is already present and there is no evidence of liquid nitrogen mustard on the skin. Protective ointment should be liberally applied, thoroughly rubbed into the affected area for about 1 minute and wiped off as completely as possible. Further cleansing may then be performed with soap and water.

(3) *Prognosis.* Most blistered areas will heal in 2 to 4 weeks if infection is prevented. Occasionally, deeper burns require a longer time.

d. Respiratory Tract. (1) *Pathology.* The lesions caused by nitrogen mustards are similar to those caused by mustard. They decrease in severity down the respiratory tract from the point of entry. In the nose, larynx, and trachea, there may be swelling, erythema, and necrosis of the mucosa, followed by sloughing, and fibrinous exudation. Laryngeal edema and necrosis may lead to respiratory obstruction. In severe cases the damage may extend to the bronchioles and alveoli. Although pulmonary edema usually is not massive, secondary pulmonary infection is common.

(2) *Symptoms.* The symptoms are much the same as those due to mustard, namely, delay in appearance, irritation of the nose and throat, hoarseness progressing to aphonia, and a persistent cough. Fever, dyspnea, and moist rales may develop. Bronchopneumonia may appear after the first 24 hours.

(3) *Treatment.* The treatment of casualties with respiratory tract involvement is the same as for mustard. (See par. 9*d* (3).)

(4) *Prognosis.* Mild tracheitis is likely to result in a persistent cough. Low grade fever may persist a week or longer. The prognosis is grave if there is a severe respiratory tract involvement. Late deaths due to pneumonia may occur.

e. Gastro-intestinal Tract. Following oral administration or systemic absorption, the nitrogen mustards cause injury to the intestinal tract. In animals severe diarrhea, which may be hemorrhagic, occurs. Lesions are most marked in the small intestine and consist of degenerative changes and necrosis in the mucosa. In man, the ingestion of 2 to 6 milligrams causes nausea and vomiting.

f. Systematic Effects. (1) *Pathology.* The most specific ef-

fects of the nitrogen mustards are on the hematopoietic and lymphoid tissue. These follow absorption from the intact skin, respiratory or gastro-intestinal tract. In bone marrow the degenerative changes can be detected within 12 hours and may progress to severe aplasia. The thymus, spleen, and lymph nodes involute rapidly with necrosis and phagocytosis of their lmphocytes. This injury is demonstrable in the blood through a transient leucocytosis of a few hours' duration, followed by severe lymphopenia, granulocytopenia, thrombocytopenia, and a moderate anemia. The blood picture may show little change other than lymphopenia for 5 to 10 days after exposure, at which time the white count may fall to 500 cells/mm.^{3} or lower. The various nitrogen mustards differ in their abilities to produce these changes.

(2) *Treatment.* The blood should be studied carefully and transfusions of whole blood given for thrombocytopenia or anemia. Vomiting or severe diarrhea may call for the replacement of fluid and electrolytes in addition to symptomatic treatment with sedatives, atropine, and opiates. If these symptoms are prolonged, every attempt should be made to maintain an adequate nutritional status by the intravenous route if necessary.

(3) *Prognosis.* Severe leucopenia, thrombocytopenia, and a loss in weight are grave manifestations.

(4) *Diagnosis.* Diagnosis is based upon a history of exposure, a faint, fishy odor on the skin and clothing, and the signs and symtoms described above.

11. Lewisite (L)

a. GENERAL. (1) Lewisite is an oily, colorless to light amber liquid, with a faint odor of geraniums. It is more volatile and less persistent than mustard. Lewisite is readily soluble in gasoline, kerosene, and alcohol. Although poorly soluble in water, it is rapidly hydrolyzed in contact with moisture. Lewisite oxide, one of the hydrolysis products, is vesicant and toxic and may contaminate ground for long periods. Lewisite, like mustard, penetrates fabrics and rubber, making it dangerous to wear clothing or rubber gloves previously contaminated.

(2) Lewisite, like mustard, injures the eyes, skin, and respiratory tract but the systemic effects are more likely to be serious than those following mustard contaminations. In contrast to liquid mustard, lewisite causes stinging pain in 10 to 30 seconds which increases in severity. Burns from field concentrations of vapor are unlikely and no decontamination or treatment is necessary following exposure unless pain is experienced. In such a case the procedures to be followed are those described in the following subparagraphs.

b. EYE. (1) *Symptoms, pathology and prognosis.* Liquid lewisite causes severe damage to the eye. On contact, pain and blepharospasm occur instantly. Edema of the conjunctiva and lids follows rapidly and closes the eye in an hour. Inflammation of the iris usually is evident by this time. After a few hours the edema of the lids begins to subside, while haziness of the cornea develops and iritis increases. The corneal injury, which varies with the severity of the exposure, may heal without residua, may develop pannus formation, or progress to massive necrosis. The iritis may subside without permanent impairment of vision, if the exposure was mild, or after heavy exposure hypopyon may ensue, terminating in necrosis, depigmentation of the iris, and synechia formation. Liquid lewisite instantaneously produces a gray searing of the cornea like an acid burn at the point of contact. Necrosis and sloughing of both bulbar and palpebral conjunctivae may follow very heavy exposure. All injured eyes are susceptible to secondary infection. Mild lewisite conjunctivitis in man heals in a few days without specific treatment. Severe exposure may cause permanent injury or blindness.

(2) *Decontamination of eyes.* (*a*) *Liquid.* Eyes contaminated with liquid lewisite are decontaminated by the same procedure as those contaminated with liquid mustard (par 9*b*). *Immediate decontamination is essential.* When liquid lewisite is the contaminating agent the immediate pain and blepharospasm caused by the agent is rapidly relieved by the instillation of BAL Eye Ointment.

(*b*) *Effectiveness of BAL.* BAL is effective against lewisite for a longer period of time after contamination than it is against mustard. If BAL is used within the first minute following contamination, the eye usually recovers in a few days. When used 10 minutes after contamination the eye requires several weeks to heal and usually suffers permanent damage. After 30 minutes, BAL has practically no effect. (***Caution:*** Hydrogen peroxide solutions furnished in some of the older chests is of value in treatment of skin contamination by lewisite, but must NOT be used in the eyes; they are worthless to treat eye contamination due to lewisite and are damaging to the cornea.)

c. SKIN. (1) *Symptoms.* Stinging is felt in 10 to 30 seconds after contact with liquid lewisite. This increases in severity as the lewisite penetrates and in a few minutes becomes a deep aching pain. Pain on contact with liquid lewisite usually gives sufficient warning so that decontamination may be begun promptly and deep burns will therefore occur rarely in conscious victims. After about 5 minutes contact, a gray area of dead epithelium is noted which resembles that seen in corrosive burns. Erythema and edema of the skin appear in about 30 minutes. The erythema is like that

caused by mustard but is accompanied by more pain. Itching and irritation persist only about 24 hours whether or not a blister develops. Blisters are often well developed in 12 hours and are painful at first, in contrast to the relatively painless mustard blister. After 48 to 72 hours the pain lessens.

(2) *Pathology.* Liquid lewisite produces more severe lesions of the skin than does liquid mustard. Contamination of the skin with liquid lewisite is followed after a short time by erythema. Vesication follows, and tends to cover the entire area of erythema, so that the surrounding halo of erythema is less conspicuous than with mustard blisters, although the two are often indistinguishable. Microscopically, the lewisite blister roof is slightly thicker than the mustard blister roof, consisting of almost the complete thickness of the epidermis which shows more complete coagulation necrosis and less disintegrative necrosis than that of the mustard blister. The yellowish blister fluid is slightly more opaque than that of the mustard blister, and, microscopically, contains a greater number of inflammatory cells. It contains a trace of arsenic an analysis, but is nontoxic and nonvesicant. Within the corium and subcutaneous tissue there is deeper injury to the connective tissue and muscle, greater vascular damage, and more severe inflammatory reaction than is exhibited in mustard burns. In large, deep, lewisite burns, there may be considerable necrosis of tissue, gangrene, and slough.

(3) *Prognosis.* Lewisite erythema usually recedes more rapidly than mustard erythema and with less pigmentation. Small lewisite blisters heal in about the same time as those due to mustard. Larger lewisite lesions may involve deep injuries which heal slowly and require skin grafts. Sensitization to lewisite after repeated burns occurs as with mustard.

(4) *Decontamination of Skin.* (*a*) *Vapor.* The risk of skin burns from field concentrations of lewisite vapor is small and decontamination of the skin for such exposure should seldom be required. When drops of liquid lewisite contaminate the clothing, concentrated vapor from these drops penetrates the cloth and damage the underlying skin. Such clothing must be removed promptly. Decontamination of skin may be accomplished if specific measures are taken within a few minutes after contact. (See (5) below.)

(*b*) *Liquid.* The removal of liquid lewisite from the skin is the individual responsibility of all ranks in all branches. If the skin is wet with lewisite, the excess liquid is quickly removed by blotting with cotton or other absorbent. Protective ointment M–5 or BAL ointment (Med. Dept. item No. 9102800) for skin decontamination is then immediately applied as described in (5) below.

(5) *Decontaminants.* The individual issue of M–5 protective ointment is highly effective in decontaminating lewisite on the skin

and should be applied as described for mustard (par. 9*c* (9)). It will decontaminate only such lewisite as remains *on* the skin. BAL ointment or BAL Solution (Med. Dept. item No. 9109525) are effective against all arsenical blister gases *on* the skin and penetrate through the skin, neutralizing the agent which has been absorbed. For this reason they are more desirable than protective ointment M–5 and should be used if available. The individual issue of eye ointment BAL (not a Med. Dept. item) in the 3-gram ophthalmic tube is to be reserved for *eye* contaminations only. The BAL ointment or solution is spread on the skin in a thin film, rubbed in with the fingers and allowed to remain at least 5 minutes. The film may be washed off when circumstances permit. The strong "rotten-egg" odor of BAL preparation must be considered in close night fighting. BAL preparation sometimes cause temporary stinging and itching urticarial wheals when applied to the skin. These lesions usually last only an hour or so and should not cause alarm. Mild dermatitis is fairly frequent if repeated applications are made to the same skin area. This prevents the use of BAL ointment as a protective film. If protective ointment, or a BAL preparation, is not available wash immediately with soap and water. Organic solvents are moderately effective in preventing blisters and then only when used in the first few seconds after exposure. Care must be taken to avoid spreading the solution of the agent to adjacent areas.

(6) *Treatment for wounded.* Wounded men, contaminated with liquid lewisite, will seldom be received at field installations in time to prevent blistering. However, their burns may be lessened and significant systemic protection obtained if the procedures outlined in *e*(3) below are carried out promptly.

(7) *Decontamination of hair.* Contaminated hair may be clipped off or decontaminated with BAL solution or ointment and then washed with soap and water.

(8) *Treatment of lewisite erythema.* The treatment of lewisite erythema is the same as that for mustard erythema, except that treatment seldom is required for longer than 24 hours (par. 9*c* (4)). BAL ointment may be tried in the early stages.

(9) *Treatment of lewisite blister.* Lewisite and mustard blisters are treated alike. (See par. 9*c* (5).)

(10) *Treatment of denuded areas and infected lewisite burns.* The treatment of these lesions is the same as that for similar lesions due to mustard. (See par. 9*c* (6) and (7).)

(11) *Treatment of deep lewisite burns.* Large burns may be accompanied by serious systemic poisoning and shock demanding general measures as well as local treatment. Morphine and splinting of the affected parts may be necessary for the relief of pain.

When the burned tissue becomes gangrenous, it should be treated in accordance with appendix V as for thermal burns.

d. RESPIRATORY TRACT. (1) *Symptoms.* Lewisite vapor is highly irritating to the respiratory tract and quickly induces sneezing and coughing. This property, together with the strong odor of geraniums, so effectively warns of the presence of the gas that no severe respiratory injuries are likely to occur. Inhaled lewisite vapor produces lesions of the respiratory mucosa essentially similar to those produced by mustard. Edema of the lung often is more marked, and is frequently accompanied by pleural fluid.

(2) *Treatment of respiratory tract injury due to lewisite.* Since there have been no human respiratory tract injuries from lewisite, treatment is recommended solely from the results of animal experimentation. In general, the treatment is a combination of that for the systemic effects of lewisite (see *e*(3) below) plus that for mustard respiratory tract injuries. (See par. 9*d* (3).)

(3) *Prognosis.* The prognosis in respiratory tract injuries from lewisite is unknown but probably is similar to that for an equivalent mustard injury, with the added danger of systemic arsenical poisoning unless treatment with BAL preparations is instituted.

e. SYSTEMIC. (1) *Pathology and symptoms.* Liquid lewisite on the skin, as well as inhaled vapor, is absorbed and may cause systemic poisoning. A manifestation of this is a change in capillary permeability which permits loss of sufficient fluid from the blood stream to cause hemoconcentration, shock and death. In nonfatal cases hemolysis of erythrocytes has occurred with a resultant hemolytic anemia. The excretion of oxidized lewisite into the bile by the liver produces focal necrosis of that organ, necrosis of the mucosa of the biliary passages with peribiliary hemorrhages, and some injury to the intestinal mucosa. Acute systemic poisoning from large skin burns causes pulmonary edema, diarrhea, restlessness, weakness, subnormal temperature and low blood pressure in animals.

(2) *Prognosis.* Burns severe enough to cause shock and systemic poisoning are dangerous to life. Even though the patient survives the acute effects, the prognosis must be guarded for several weeks.

(3) *Treatment.* There has been no experience in treating systemic lewisite poisoning in man, but the following measures may be of value:

(*a*) *Indications for treatment.* The indications for systemic treatment following exposure to arsenical blister gases by any route are:

1. Cough with dyspnea and frothy sputum, which may be blood-tinged and other signs of pulmonary edema.

2. A skin burn the size of the palm of the hand, or larger, caused by a *liquid* arsenical blister gas, *which was not decontaminated within the first 15 minutes.*

3. A skin contamination covering 5 percent (about one square foot) or more of the body surface caused by a liquid arsenical vesicant, in which evidence of immediate skin damage (gray or dead-white blanching of the skin) or erythema develops over the area within 30 minutes.

4. In cases seen late where there is blistering of skin areas the size of the palm of the hand or larger.

(*b*) Two types of treatment are *required.*

1. Intramuscular injection of 10 percent BAL in oil. (Med. Dept. item No. 1088500). (See (*c*) below.)

2. Local neutralization on and within the skin by a liberal inunction of BAL ointment (Med. Dept. item No. 9102810). The affected skin is to be left covered with a layer of the ointment. Any protective ointment must first be removed from the area to be treated by BAL.

(*c*) *Dosage of BAL in Oil.*

1. An immediate intramuscular injection of 10 per cent BAL in Oil (Med. Dept. item No. 1088500) is given deep into the muscles of the buttocks. Take every precaution against injecting into a blood vessel. Dosage must be adjusted to the estimated weight of the patient as follows:

125 pounds.....2.5 c.c.	175 pounds.....3.5 c.c.
150 pounds.....3.0 c.c.	200 pounds.....4.0 c.c.

2. The intramuscular injection of 10 per cent BAL in Oil should be repeated at different sites in the buttocks at 4, 8 and 12 hours after the initial injection, making a total of four equal doses.

3. If pulmonary symptoms or other evidence of severe arsenical poisoning are present, the interval between the first and second dose may be shortened to 2 hours. In severe cases subsequent daily *half* doses should be given at the rate of one injection per day for 3 or 4 days.

4. In toxic or shocked patients, the usual measures such as plasma, high vitamin, high protein, high carbohydrate diets; liberal fluids by mouth or intraveneously if necessary are to be employed as indicated.

(*d*) Symptoms caused by BAL in Oil. These may include a feeling of constriction in the throat, sense of oppression in the chest, burning sensation of the lips, mild lacrimation, slight reddening of the eyes, dryness of mouth and throat, generalized muscular aching, abdominal pain, mild to moderate tenderness and increased

muscle tonus at injection site, mild restlessness and nervousness with sweating of the hands, apprehension, mild nausea and vomiting on eating, and a transient rise in blood pressure. Symptoms appear 15 to 30 minutes after injection and last 30 minutes. Unless unduly severe or prolonged, they do not contraindicate the full course of treatment.

12. Ethyldichlorarsine (ED)

a. PROPERTIES. Ethyldichlorarsine is a colorless or brown liquid which is more volatile than lewisite and possesses a faint fruity odor.

b. PATHOLOGY. The lesions are the same as those caused by lewisite. (See par. 11*a* and *b* (1).)

c. SYMPTOMS. Low concentrations of vapor produce no symptoms for the first minute. Stinging pain in the nose, a burning sensation in the throat, headache, nausea and vomiting then begin. Even though the gas mask is put on at once. Symptoms may increase for several minutes before they regress. High concentrations are instantly so irritating to the eyes and respiratory tract that they compel wearing of the gas mask. A stinging and burning sensation is felt on the skin within 1 or 2 minutes. In very hot weather, this may progress to redness in 10 minutes, and to shallow blistering in a few hours. Pain persists only about 24 hours, and the blisters crust over in a few days and heal rapidly. Liquid ethyldichlorarsine, like lewisite, is immediately painful on the skin and causes severe blistering. It produces eye injuries similar to but less severe than those due to lewisite.

d. DIAGNOSIS. The following factors should be considered in making the diagnosis:

(1) History of exposure.

(2) Fruity odor of skin and clothing.

(3) Intense sternutatory irritant, and early vesicant effect.

e. DECONTAMINATION. Decontaminating procedures are identical with those for lewisite. (See par. 11*b* (2), *c* (4), (5), and (6).)

f. TREATMENT. Treatment of mild respiratory tract irritation is the same as that for DM (par. 17*d*). After decontamination, eye and skin lesions are treated as those due to mustard. (See par. 9*b*(4) and (5), *c*(4), (5), (6), (7), and (8).) BAL preparations may be used if indicated as prescribed for lewisite (par. 11*c*(4) *e*(3).)

g. PROGNOSIS. Respiratory tract irritation from low vapor concentrations subsides within an hour. Skin burns in general, heal more rapidly than similar mustard burns. Liquid ethyldichlorarsine contamination in the eye causes serious injury, possibly blind-

ness, unless a BAL preparation is promptly administered. See par. 11*b*(2).)

13. Phenyldichlorarsine (PD)

a. PROPERTIES. This agent, a clear viscid liquid, is less volatile than lewisite or ethyldichlorasine. It is readily hydrolyzed in water.

b. ACTION. Phenyldichlorarsine, when inhaled, is a strong sternutator and lung irritant. Eye injury produced is similar to that caused by lewisite. (See par. 11*b*(1).) On the skin the vapor or liquid is only slightly less vesicant than mustard or lewisite. If absorbed, phenyldichlorarsine may produce systemic poisoning.

c. PATHOLOGY. The lesions and the systemic effects produced by phenyldichlorarsine are essentially those of lewisite.

d. SYMPTOMS. Irritation of the eyes, nose, and throat is prominent. Symptoms referable to the lungs and skin are like those produced by lewisite. (See par. 11*c*(1) and *d*(1).)

e. TREATMENT. Treatment in general is the same as that described for lewisite. (See par. 11*c*(4) and *e*(3).)

14. Mixed Blister Gases

a. GENERAL. Arsenical vesicants, such as lewisite (L) or phenyldichlorarsine (PD) are often mixed with mustard. Such mixtures do not produce more severe lesions than either agent alone, but they tend to confuse and make diagnosis difficult.

b. DECONTAMINATION. (1) *Eyes.* Eyes contaminated by a mixture of liquid blister gases are treated in the same fashion as in the case of mustard (par. 9*b*). The arsenical vesicant portion of the agent will produce pain and blepharospasm which will probably necessitate working the ointment between the lids, as for lewisite, before the soldier is able to open his eyes.

(2) *Skin.* Any excess of the liquid mixture is blotted from the skin at once. Protective ointment is then applied as described under mustard (par. 9*c*(9)). The ointment is thoroughly removed and a BAL preparation, if available, is rubbed on as for lewisite (par. 11*c*(4) and (5)). This should be removed immediately and applied again.

c. TREATMENT. (1) *Eyes.* Definitive treatment of eye injuries due to mixtures is like that for mustard injury of the eye. (See par. 9*b*(4) and (5).)

(2) *Skin.* Definitive treatment of skin lesions produced by mixtures is like that described for lewisite burns. (See par. 11*c* (8), (9), (10).)

SECTION IV

LACRIMATORS

15. Symptoms and Treatment

a. The more important lacrimators are chloracetophenone (CN), chloracetophenone solutions (CNS and CNB), and brombenzyl cyanide (BBC).

b. General symptoms produced by the lacrimators include lacrimation, photophobia, blepharospasm and some irritation of the nose and of the freshly shaven face. In hot weather moist skin will not be irritated. In addition, chloracetophenone solutions CNS and CNB may cause some mild papulovesicular dermatitis, especially in warm weather, and occasional vomiting. Lacrimator casualties ordinarily do not require medical attention.

c. First Aid and Treatment. (1) *First aid.* The mask should be put on and rapid breathing maintained to aid circulation of air in the mask. The eyes are kept open as much as possible. They should not be rubbed. If a liquid or solid agent has entered the eye, it should be promptly washed out with water from the canteen.

(2) *Treatment.* (*a*) *Eyes.* Lacrimators produce a marked but self-limited irritation of the conjunctiva. When liquid lacrimators are splashed into the eye, the action is corrosive and resembles the burns of a strong acid. The eye should be flushed immediately with water from the canteen. This may be followed by the instillation into the eye of a solution of sodium sulfite (¼ percent), if available, which dissolves and neutralizes the irritating agent. Eye pain may be treated by instilling eye and nose drops (Med. Dept. item No. 9109100). The further treatment is as for other burns of the eye.

(*b*) *Skin.* Superficial skin burns may be treated by calamine lotion for symptomatic relief. Deep burns should be treated as other skin burns.

SECTION V

VOMITING GASES (NOSE GASES, IRRITANT SMOKES, STERNUTATORS)

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16. General

a. The vomiting gases, diphenylaminechlorarsine (DM, adamsite), diphenylchlorarsine (DA), and diphenylcyanarsine (DC) are crystalline solids which are dispersed by heat as fine particulate smokes. DM smoke is canary yellow near the point of emission, while those of DA and DC are white; all are colorless when diluted with air. Low concentrations are effective and smell like burning fireworks.

b. These agents produce strong pepperlike irritation in the respiratory tract, most pronounced in the trachea and large bronchi. The onset of symptoms may be delayed for several minutes, especially with DM, and effective exposure therefore may occur before the presence of the smoke is suspected. If the gas mask is then put on, symptoms will increase for several minutes, in spite of adequate protection. The soldier may believe his mask is ineffective, remove it, and be further exposed. This is disastrous if the smoke is immediately followed by a lethal gas.

c. Both the service gas mask and the collective protector offer adequate protection against these agents.

17. Diphenylaminechlorarsine (DM) (Adamsite)

a. PATHOLOGY. DM produces local inflammation of the nose, nasal accessory sinuses, throat and eyes.

b. SYMPTOMS. These consist of pain and a sense of fullness in the nose and sinuses, accompanied by a severe headache, intense burning in the throat, and tightness and pain in the chest. Irritation of the eyes and lacrimation are produced. Coughing is uncontrollable and sneezing is violent and persistent. The nasal secretion is greatly increased and quantities of ropy saliva flow from the mouth. Nausea and vomiting are prominent. Mental depression may occur.

c. DIAGNOSIS. This is made from the history of exposure and the relatively rapid spontaneous improvement which occurs despite the original miserable appearance and condition of the individual.

d. TREATMENT. The mask must be worn in spite of nausea and salivation, but it should be lifted from the face during actual vomiting. Frequent inhalations of chloroform (Medical Department item No. 9105800) administered early, give relief. Aspirin may be given to relieve the headache and general discomfort. Few cases should reach the medical service for treatment, since recovery is prompt and the soldier can carry out his battle mission in spite of sternutators.

e. PROGNOSIS. Ordinarily all symptoms disappear in about 1 to 2 hours. Permanent injury is unlikely following exposure to field concentrations. Exposure in confined spaces may produce pulmonary injury and death.

18. Diphenylchlorarsine (DA), Diphenylcyanarsine (DC)

The pathology, symptoms, diagnosis, treatment, and prognosis are similar to those diphenylaminechlorarsine (DM). (See par. 17.)

SECTION VI

SCREENING SMOKES

19. General

The most important of these agents are HC mixture (HC), sulfur trioxide-chlorsulfonic acid (FS), and titanium tetrachloride (FM). These smokes are not toxic in field concentrations, but may be dangerous in the heavy concentrations formed at the site of dispersion.

20. White Phosphorus (WP)

See paragraph 27.

21. Titanium Tetrachloride (FM)

a. PATHOLOGY. The liquid produces acid burns.

b. SYMPTOMS. Smoke generated by liquid FM is unpleasant to breathe as it irritates the nose and throat, but it is not dangerous in field concentrations. Exposure of the eyes to spray will cause conjunctivitis, with lacrimation and photophobia. Skin burns like those from acids are produced by contact with the liquid.

c. TREATMENT. The burned eyes or skin should be thoroughly washed with water and then treated like any other burn.

d. PROGNOSIS. Good.

22. Sulfur Trioxide-chlorsulfonic Acid Solution (FS)

a. PATHOLOGY. Acid burns are produced by contact with the liquid.

b. SYMPTOMS. These are usually limited to a prickling sensation of the skin, but exposure to heavy concentrations may result in severe irritation of the eyes, skin, and respiratory tract.

c. TREATMENT. The eye is irrigated with water at once. Fluorescein (Medical Department item No. 9116300) will reveal corneal ulceration. For pain, eye and nose drops (Medical Department item No. 9109100) may be instilled. The eye is then covered with a light pad. Skin burns should be washed with water and then with sodium bicarbonate solution. Later treatment should be that employed for other burns.

d. PROGNOSIS. The prognosis depends on the degree of corneal ulceration. The prognosis of skin burns and respiratory irritation is good.

23. HC Mixture (HC)

a. TOXICITY. Field concentrations of this smoke are harmless, but dangerous to fatal levels may be encountered in poorly ventilated spaces or near the point of smoke production.

b. PATHOLOGY. HC smoke, if inhaled, damages the respiratory tract by the action of the contained zinc chloride. Following severe exposure a chemical pneumonia with pulmonary edema may develop as in phosgene poisoning.

c. SYMPTOMS. When HC is breathed in high concentrations there is a feeling of suffocation and some irritation of the nose and throat with coughing and choking. This may be followed by bronchial constriction with symptoms similar to those of asthma; severe exposures produce nausea and vomiting, and later, signs and symptoms of pulmonary edema may appear.

d. Treatment. The early symptoms due to bronchial constriction may be relieved by the intramuscular injection of 0.5 mg. (0.5 cc. of a 1:1000 solution) of epinephrine hydrochloride. This dose may be repeated in 20 to 30 minutes if necessary. If the exposure has been heavy, treatment with intramuscular BAL in oil should be instituted. The dose and procedure are the same as for systemic L poisoning (par. 11*e*(3)(*c*)) except that injections are continued for 48 hours at 4-hour intervals. Should pulmonary edema develop, treatment is like that for phosgene poisoning (par. 5*d*).

e. PROGNOSIS. The prognosis depends on the severity of exposure and the extent of pulmonary damage.

SECTION VII

INCENDIARY AGENTS

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24. General

The principal agents in this group are thermite (TH), magnesium and its alloys, white phosphorus (WP), and combustible oils. All generate tremendous heat and can inflict severe burns. Chemical fire extinguishers containing carbon tetrachloride (pyrene) or liberating carbon dioxide should not be used in confined spaces to extinguish thermite and magnesium incendiary bombs. When carbon tetrachloride comes in contact with flame or a highly heated metal, a mixture of phosgene, chlorine, carbon monoxide, and hydrochloric acid is liberated. The service mask does not offer protection against carbon monoxide.

25. Thermite (TH)

Thermite incendiaries burn at a temperature of about 4330° F. and scatter molten iron. Frequently explosive charges are added and make control hazardous. The particles of iron that lodge in the skin usually produce multiple small but deep burns. The particles should be cooled immediately with water and removed. Thereafter the treatment is that used for other thermal burns.

26. Magnesium and Its Alloys

Magnesium burns at a temperature of about 3630° F. with a scattering effect similar to that of thermite. Deep burns are caused by its particles, which, unless removed promptly, result in slow healing. Removal is usually possible under local anesthesia. When explosive charges have been added to a magnesium bomb, the fragments may be embedded deep in the tissues, causing the localized formation of hydrogen gas and tissue necrosis.

27. White Phosphorus (WP)

Extensive burns may be produced by incandescent particles of white phosphorus. The burns are usually multiple, deep, and variable in size. The smoke is nontoxic in field concentrations. White phosphorus continues to burn unless deprived of oxygen.

The burned areas should be immersed immediately in water or covered with dressings soaked in water, urine, or any nonirritant aqueous solution. Immersion should be continued until a 5 percent solution of copper sulfate (Medical Department item No. 9107500) is applied. A 2 percent solution of copper sulfate may be used in the eye. Copper sulfate forms a noninflammable coating of black copper phosphide on the phosphorus particles. All particles should be removed under water, unless the copper sulfate solution has been applied. They may be located by their phosphorescence in the dark. Burning particles are recognizable by the evolution of smoke. It is well to debride the burn promptly, if the patients condition will permit, in order to remove bits of phosphorus which might be absorbed and produce systemic poisoning. Following the removal of the particles the lesions are treated as thermal burns. Salves with an oily base should not be used until it is certain that all phosphorus has been removed.

28. Oil Incendiaries

a. Burns may be produced by flame throwers and by oil incendiary bombs which may also contain phosphorus and sodium. Lung damage from heat and irritating gases may be a complication added to the injuries from incendiaries, especially in confined spaces. Morphine should be given guardedly to patients with pulmonary complications. The treatment of burns caused by oil incendiaries is like that for other heat burns.

b. FLAME THROWER ATTACK. (1) *General.* As flame from burning fuel fills an inclosed fortification the oxygen content of the air is reduced and hot fumes and smoke are produced. The coolest and purest air is found at floor level.

(2) *Casualties.* Deaths may occur during or shortly after flame attack. Survivors may have thermal burns of the skin and upper respiratory tract as well as pulmonary damage from fumes. Laryngeal and glottic edema may cause suffocation.

(3) *Protection.* The floor level is the safest area during flame attack. Any kind of cover affords some protection from heat. A wool blanket is excellent. The gas mask should be worn for the protection it affords against smoke and for its slight cooling effect on the inspired air.

(4) *Treatment.* Casualties should be removed to fresh air as soon as possible. Artificial respiration (with the inhalation of 100 percent oxygen if possible) should be instituted if breathing has ceased. Burns of the skin are treated as any thermal burns (app. V). If there are burns about the face, the possibility of laryngeal burning with subsequent edema producing respiratory obstruction should be borne in mind so that tracheotomy can be

performed in an emergency. The general treatment of the casualty burned by flame attack does not differ from that given for any extensive thermal burns. Plasma is given for the prevention of shock and other procedures outlined in app. V are followed.

SECTION VIII

SYSTEMIC POISONS

29. General

Systemic poisons produce their effects after absorption into the body. Hydrocyanic acid, cyanogen chloride and arsine are included in this group.

30. Hydrocyanic Acid (AC)

a. PHYSICAL PROPERTIES. Hydrocyanic acid is a colorless, highly volatile liquid which boils at 26° C. Its vapor is nonpersistent and its odor is faint, like peach kernals or bitter almonds, but undetectable to some.

b. PATHOLOGY. Hydrocyanic acid acts by combination with an enzyme essential for oxidative processes of the tissue. The central nervous system, particularly the respiratory center, is especially susceptible to this interference, and respiratory failure is the usual cause of death. In high concentrations of hydracyanic acid (10 mg per liter or more) the amount inhaled in a few breaths may be sufficient to cause immediate death without anatomical changes. After exposure to lower concentrations, death may be delayed for hours to days. Small areas of hemorrhage and softening, the more pronounced the longer the course, may be found in the brain in fatal cases.

c. SYMPTOMS. The symptoms depend upon the concentration of the gas and the duration of the exposure. In high concentrations there is increased depth of respiration within a few seconds; violent convulsions after 20 to 30 seconds; cessation of regular respiration in 1 minute; occasional shallow gasps, and finally, cessation of heart action several minutes after initial exposure. Following moderate exposures, vertigo, nausea, and headache appear very early and are followed by coma and convulsions. These may persist for several hours or days and be followed by death or recovery. If the patient recovers after a prolonged course during which coma and convulsions were present, there may be evidence of damage to the central nervous system, such as irrationality, altered reflexes and unsteady gait, which may last weeks or

longer. Mild exposure may produce headaches, vertigo, and nausea, but recovery is complete.

d. DIAGNOSIS. The diagnosis may be made from the history, the odor, and the rapid onset of symptoms.

e. TREATMENT. (1) Adequate protection against field concentrations of AC is provided by all army gas masks of M9A2 or later model of canister. The most practicable therapeutic measure at present available is the inhalation of amyl nitrite. In the event that use of hydrocyanic acid by the enemy is anticipated in a specific combat zone, ampouls of amyl nitrite (Medical Department item No. 1069000) should be distributed to each soldier. When hydrocyanic acid is detected, the soldier must attempt to hold his breath and adjust his gas mask. If he is capable of doing this, the hydrocyanic acid already absorbed will usually be detoxified. However, if the soldier is incapacitated (disorientation, coma, or convulsions) emergency treatment must be given immediately by the nearest individual. If hydrocyanic acid is still present in the atmosphere and the stricken soldier has not been able to put on his gas mask, this must be done for him. The soldier should be placed on the ground in a horizontal position. Two ampouls of amyl nitrite are crushed and inserted under the facepiece. Since the patient will usually not be breathing, or breathing feebly or irregularly, manual artificial respiration must be instituted to facilitate the inhalation of the amyl nitrite. The insertion of two crushed ampouls of amyl nitrite is repeated three times at 3- to 4-minute intervals until a total of eight ampouls is given. If hydrocyanic acid is gone from the surrounding atmosphere within a few seconds after the soldier is stricken and the gas mask has not been put on, time should not be taken to adjust the mask. Two ampouls of amyl nitrite may be crushed in the hollow of the hand and held close to the patient's nose. As above, administration is repeated every 3 or 4 minutes until a total of eight ampouls is given. Artificial respiration should be continued until spontaneous regular respiration returns. Treatment should be continued for at least 10 minutes after the last sign of cardiac activity.

(2) Where available, sodium nitrite and sodium thiosulfate should be administered intravenously. Then cc. of a 1 percent solution of sodium nitrite should be injected intravenously over a period of 1 minute every 10 minutes until a total of 50 cc. is given. Between the nitrite injections, 10 cc. of a 10 percent solution of sodium thiosulfate (Medical Department item No. 1449500) should be given intravenously over a period of 1 minute.

(3) Amyl nitrite administration may lead to a marked but temporary and not dangerous fall in blood pressure. The decrease

in blood pressure following sodium nitrite injections is negligible unless the patient is allowed to get into an upright position. The development of a slight degree of cyanosis is evidence of a desirable degree of methemoblobinemia. It is not anticipated that, at the above dosages, an extreme or injurious degree of methemoglobinemia will develop. If it does, however, it should be treated by 100 percent oxygen inhalation.

31. Cyanogen Chloride (CK)

a. PROPERTIES. Cyanogen chloride is a colorless liquid which boils at 15°C. yielding a volatile irritant vapor. Although only slightly soluble in water, it dissolves readily in organic solvents.

b. PATHOLOGY. The acute toxicity of cyanogen chloride is similar to that of hydrocyanic acid. The respiratory center is at first stimulated and then rapidly paralyzed. Cyanogen chloride, like phosgene damages the respiratory tract resulting in mild inflammatory changes in the bronchioles, and congestion and edema of the lungs. The edema may form much more rapidly than in phosgene poisoning.

c. SYMPTOMS. The signs and symptoms combine those produced by a lung irritant and hydrocyanic acid. Very low concentrations produce lacrimation. Following exposure there is an immediate intense irritation of the nose, throat and eyes, with coughing, choking, tightness in the chest, and lacrimation. Thereafter the exposed person may become dizzy and increasingly dyspneic. Unconsciousness is followed by failing respiration and death within a few minutes. Convulsions, retching, involuntary urination and defecation may occur. If these effects, typical of cyanide poisoning, are not fatal, the signs and symptoms of pulmonary edema may develop. There may be persistent cough with much frothy sputum, rales in the chest, severe dyspnea and marked cyanosis.

d. TREATMENT. Adequate protection against field concentrations of CK is provided by all army gas masks of later model than the one with carister M1XA1. On detection of the gas, the breath should be held and the gas mask should be adjusted. Treatment is a combination of those for hydrocyanic acid and for phosgene poisoning. (See pars. 5*d* and 30*e*.) The predominant signs and symptoms determine therapy.

e. PROGNOSIS. If death does not occur promptly from cyanide, the outlook is determined by the severity of the manifastations of lung irritation.

32. Arsine (SA)

a. PROPERTIES. Arsine is a colorless, odorless gas, but when impure it may have a garliclike odor in high concentrations.

b. PATHOLOGY. The gas is absorbed from the respiratory tract into the blood and gives rise to intravascular hemolysis. This results in anemia, hemoglobinemia, methemoglobinemia and hemoglobinuria. Through the action of circulating arsine and its oxidation products there is serious disturbance of the tissue metabolism of kidney and liver. The kidneys show marked tubular change and numerous blood pigment casts. Anatomical changes in the liver are less constant, but hepatitis and focal necrosis may be present. Jaundice is due to hemolysis or to liver damage or both. Death results from renal or hepatic failure, anemia, or a combination of these.

c. TREATMENT. Therapy is both symptomatic and specific. The symptomatic treatment consists in: the daily administration of about 3000 cc. fluid, either orally or parenterally as isotonic saline and glucose; blood transfusions of 500 cc. each, repeated so as to maintain the hemoglobin above 50 percent and the r.b.c. count above two million per cu. mm.; the daily administration of 20 gm. sodium bicarbonate in divided doses. The specific treatment is the same as that for lewisite poisoning and consists in the intramuscular injection of BAL (par. 11*e*(3) (*a*), (*c*), and (*d*)).

SECTION IX

INCIDENTAL GASES

33. General

a. This group includes carbon monoxide, nitrous fumes, hydrogen sulfide and ammonia. These may be encountered in dangerous concentrations in confined or poorly ventilated spaces.

b. Protection against incidental gases. The service mask and collective protectors are not efficient against carbon monoxide or ammonia. Special canisters are available.

34. Carbon Monoxide

a. PHYSICAL PROPERTIES. Carbon monoxide is a colorless, odorless gas, which is lighter than air, into which it diffuses rapidly.

b. OCCURENCE IN MILITARY OPERATIONS. Carbon monoxide is formed by gun blasts, bursting shells, internal combustion engines, and in the incomplete combustion of fuels. Dangerous concentrations are apt to occur in confined spaces such as tank landing craft, garages, poorly ventilated gun turrents or emplacements, and in mining operations.

c. PATHOLOGY. Asphyxiation is produced by the inactivation of hemoglobin through combination with carbon monoxide. The resultant anoxia produces nervous system changes. Post mortem examinations reveal little beyond the characteristic cherry red color of the blood and hemorrhages in the brain. The dissociation of carbon monoxide from hemoglobin may be hastened by oxygen.

d. SYMPTOMS. The symptoms progress from throbbing headache, vertigo, yawning, and poor visual acuity, to the development of cherry red mucous membranes, weakness and coma, subnormal temperature, feeble pulse and perhaps death.

e. DIAGNOSIS. The diagnosis is made from circumstances of exposure and the appearance of cherry red color of the skin and mucous membranes.

f. PROTECTION. Adequate ventilation should be provided for all inclosed space where carbon monoxide may be produced. The safety of the air in the space may be tested by introducing a cage containing a mouse or canary. The air will be safe for man to breath as long as these remain unaffected. *Caution:* This test can

only be relied upon at atmospheric or higher pressures. At high altitudes it is not reliable.

g. TREATMENT. Remove to pure air, give oxygen and artificial respiration if necessary. Rest, blankets, and warm drinks are also indicated.

h. PROGNOSIS. The longer the period of coma the less the chance for recovery. Most mildly exposed individuals recover with early treatment. Tachycardia and dyspnea may continue for months and there may be central nervous system disturbances ranging from simple neuritis to mental deterioration.

35. Nitrous Fumes

a. GENERAL. The term "Nitrous fumes" applies to the mixture of oxides of nitrogen which is liberated when high explosives are burned or detonated. Nitrous oxide has anesthetic properties in high concentrations. It possesses no irritating action. Nitric oxide combines rapidly with oxygen to form nitrogen dioxide which is a dark brown gas. Nitrogen dioxide reforms nitric oxide when it passes through the gas mask. Nitrogen dioxide also forms N_2O_4. The latter compound reacts with water to form nitrous and nitric acid.

b. OCCURRENCE OF POISONING. The danger of nitrous fume poisining is great if high explosives, such as smokeless powder or cordite, are burned or detonated in the absence of sufficient ventilation. This may occur in gun pits, armored vehicles, ship magazine and turrets, as well as in mining and tunneling operations.

c. PATHOLOGY. Nitric oxide, NO, combines with hemoglobin to form NO-hemoglobin. It is doubtful, however, whether this latter compound exists in the body during life. Inhalation of nitric oxide causes the formation of methemoglobin but does not appear to lead to any tissue lesions. Inhalation of nitrogen dioxide results in the formation of nitrite and hence leads to a fall in blood pressure and to the production of methemoglobin. Inhalation of high concentrations of nitrogen dioxide (above 0.5 mg. per liter) causes rapid death without the formation of pulmonary edema. Somewhat lower concentrations result in death with the production of yellow frothy fluid in the nasal passages, mouth and trachea and marked pulmonary edema. The findings in other tissues are negligible.

d. SYMPTOMS. The symptoms following inhalation of "nitrous fumes" are due chiefly to nitrogen dioxide. The symptoms depend upon the concentration of the gas. At exposures to concentrations less than 0.005 mg. per liter over long periods of time, inflammation of the gums, emphysema of the lungs, hypotonia and bradycardia have been observed. At exposure to higher concentrations,

there is severe local irritation with burning and choking in the chest, violent cough, expectoration of yellow colored sputum, headache and vomiting. A latent period of 2 to 24 hours then follows. The late symptoms start with coughing, nausea, vomiting, frothy sputum, dyspnea, cyanosis, convulsions and symptoms of lung edema. This train of symptoms may result in death. At exposures to very high concentrations for short periods of time, the onset of symptoms is very sudden and marked. Convulsions, unconsciousness and respiratory arrest occur within a short time and death may follow.

e. DIAGNOSIS. The diagnosis is made from the history, the symptoms described, and sometimes from the pungent odor of the gas or the yellow discoloration of the exposed mucous membranes.

f. TREATMENT. Treatment of casualties with symptoms of pulmonary irritation is the same as that outlined for phosgene poisoning (par. 5*d*). The few cases with symptoms referable to the central nervous system either die quickly or, on removal to fresh air, recover spontaneously.

g. PROGNOSIS. Fatal cases usually die within 48 hours. Bronchopneumonia and varying degrees of pulmonary fibrosis and emphysema often follow recovery from the acute stage.

36. Hydrogen Sulfide

a. This colorless gas in low concentrations has the odor of rotten eggs. In high concentrations it may dull the sense of smell and be difficult to recognize. Hydrogen sulfide is nearly as toxic as hydrocyanic acid.

b. PATHOLOGY. In low concentrations, less than about 0.5 mg. per liter, hydrogen sulfide may produce inflammation of the eyes, nose and throat if breathed for periods of ½ to 1 hour or longer. Somewhat higher concentrations may produce edema of the lungs. Still higher concentrations, 2 mg. per liter or greater, are rapidly fatal, presumably by combination of the hydrogen sulfide with the tissue respiratory pigments and the subsequent paralysis of the respiratory center.

c. SYMPTOMS. The symptoms depend upon the concentration of the gas. At the lowest concentrations, the effects are chiefly on the eyes: conjunctivitis, swollen eye-lids, itchiness, smarting, pain, photophobia, and blurring of vision. At somewhat higher concentrations, respiratory tract symptoms are more pronounced. Rhinitis, pharyngitis, laryngitis, and bronchitis may occur. Pulmonary edema may also result. At very high concentrations, unconsciousness, convulsions and cessation of respiration develop rapidly.

d. TREATMENT. The patient should be removed immediately

from the contaminated atmosphere. Aritficial respiration and, if possible, inhalation of oxygen should be instituted immediately. Treatment of pulmonary edema is the same as of that caused by phosgene (par. 5*d*).

e. PROGNOSIS. Mortality from severe exposure is high. When there are symptoms of lung damage the prognosis is like that in phophosgene poisoning (par. 5*f*).

37. Ammonia

a. PHYSICAL PROPERTIES. Ammonia is a colorless gas which is soluble in water and has a pungent, characteristic odor.

b. OCCURRENCE IN MILITARY OPERATIONS. This gas has not been used in warfare but may be encountered in industrial accidents and bombings involving refrigeration plants.

c. PATHOLOGY. Exposure to high concentrations of ammonia produces prompt and violent irritation of the eye and respiratory tract. There may be spasm and edema of the glottis of even necrosis of the laryngeal mucous membranes. Pulmonary edema may develop as in phosgene poisoning and may be complicated by bronchopneumonia.

d. SYMPTOMS. Inhalation of high concentrations produces violent, burning pain in the eyes and nose, lacrimation, sneezing, pain in the chest, cough, spasm of the glottis, and pulmonary edema. Often there is a temporary reflex cessation of respiration with spasm of the glottis. Edema of the glottis at a later period may seriously interfere with breathing. Concentrations of 0.1 percent are intolerable to man. Liquid ammonia is vesicant.

e. TREATMENT. First-aid treatment consists of prompt removal to pure air, and artificial respiration. Later measures are directed toward the treatment of pulmonary edema, bronchitis and pneumonia. (See par. 5*d*).

f. PROGNOSIS. The mortality is high following severe exposure with lower concentrations, recovery is usually rapid, although bronchitis may persist.

SECTION X

OXYGEN DEFICIENCY

38. General

a. GENERAL. (1) The proportion of oxygen in the atmosphere may be reduced to a dangerous degree in closed or poorly ventilated spaces such as shelters, compartments, or underground tunnels, by human consumption, combustion by fire, or dilution with other gases. The absolute reduction of oxygen at high altitudes while mainly of concern to aviation, may also deserve consideration in land operations in mountains.

(2) A normal 70 Kg. man while resting in bed requires 0.240 1/min. of oxygen. Consumption is increased with activity to 1.2 1/min. while walking at a rate of 4 miles per hour and to 3 or 4 1/min. at maximum exertion.

b. SYMPTOMS. (1) When the oxygen of the inspired air is diminished to values between 16 and 12 percent (a candle is extinguished at 17 percent), the volume of breathing is increased and the pulse rate is accelerated. The ability to think clearly is diminished. Finer skilled movements are disturbed.

(2) When the oxygen of the inspired air is diminshed to 14 to 10 percent judgment becomes faulty, injuries may cause no pain, emotions are volatile, and muscular effort causes easy fatigue.

(3) When the oxygen is diminshed to 10 to 6 percent nausea and vomiting may appear. Bewilderment and loss of consciousness follow. Muscular movements may be impossible. The subject may be wholly unaware that anything is wrong.

(4) When the oxygen is diminshed to below 6 percent, respiration consists of gasps separated by periods of apnea. Convulsive movements may occur. Respiration ceases and the heart continues to beat for a few minutes. Death follows rapidly.

c. ACCLIMATIZATION. Initial exposure to anoxia at high altitudes may give rise to the above symptoms. After several days at high altitudes, acclimatization takes place. There is an increase in the volume of breathing and of the red cells in the blood with a decrease of the alkali in the blood and of carbon dioxide in the alveolar air. This enables the individual to increase his activity toward normal.

d. TREATMENT. (1) The individual should be removed from the atmosphere to pure air if possible. At high altitudes and where removal to air is impossible, oxygen must be administered. If respirations have ceased, artificial respiration should be given until at least 10 minutes after signs of cardiac action have disappeared. Oxygen 95 percent and carbon dioxide 5 percent should be administered by inhalation.

(2) The individual exposed to low oxygen concentrations should remain recumbent and move as little as possible in order to diminish his metabolic needs for oxygen.

(3) It is obvious that no gas mask will protect against oxygen deficiency.

e. PROGNOSIS. (1) If the anoxia is corrected before consciousness is lost or shortly thereafter, most of the symptoms disappear within a few hours. Headache, nausea, and malaise may continue for 24 to 48 hours.

(2) If anoxia has continued for a long period, degenerative changes may occur in the nervous system with paralysis or amnesia. Death occurs rapidly when the oxygen content of the inspire air drops below 6 percent.

SECTION XI

ANIMAL CASUALTIES

39. General

a. The material on human casualties from chemical warfare agents is generally applicable to animals. Hence only facts important in the handling of gassed horses, mules and dogs will be stressed.

b. The prevention of gas casualties in Army animals is important to eliminate lost working days. Animal gas masks and leg covers offer the best individual protection. Animals, especially horses, may, if masked, withstand exposure to vesicant vapors without developing incapacitating injuries. Protection by covers against airplane spray may be required. The dog gas mask provides protection for the eyes and respiratory tract. His working efficiency is so reduced when masked that he should not be expected to work in it. The feet and legs of dogs are particularly vulnerable to liquid vesicants. Animals should be prevented from drinking from water holes, trenches, or shell craters and from pasturing in areas which have recently been contaminated, until the water and forage are known to be suitable for consumption. Water in deep wells or large streams and lakes is usually safe.

40. Lung Irritants

a. GENERAL. The effects of lung irritants in animals are like those in men.

b. PHOSGENE. (1) *Symptoms.* Cyanosis, so prominent in humans, is masked in animals.

(2) *Treatment.* Heavy work is dangerous, especially after pulmonary edema develops. Animals in shock should be kept comfortably warm. Oxygen therapy for animals is not practicable under field conditions. Venesection has not proved beneficial and is certainly harmful during the shocklike stage. Contraindications in treatment are the same as those for man. If the animal survives 4 days, recovery may be expected, unless bronchopneumonia supervenes.

c. CHLORPICRIN. Chlorpicrin irritates the upper bronchi and

trachea as well as the alveoli. Pulmonary edema may appear. The clinical picture and treatment are as described for phosgene.

d. CHLORINE. Chlorine causes bronchospasm and a choking cough. If death is not immediate from intense bronchial spasm, the later symptoms and the treatment are those described for phosgene.

41. Vesicants

a. GENERAL. (1) The terms "blister" and "vesicant" agents are misnomers for animals since vesication does not occur. The vesicants, especially the arsenicals, contaminate forage, water, grain, and other supplies.

(2) Before treating vesicant casualties, veterinary personnel must be protected.

b. MUSTARD. (1) *Injury caused by mustard.* (*a*) Incapacitating injury to animals may result from liquid mustard sprayed from aircraft or splashed from shell bursts, or from contact with recently contaminated ground. Mustard vapor produces less injury to animals than to man. A long coat of hair does not prevent injury but does impede penetration of liquid and cause lateral spreading. This results in a shallow lesion with a short healing time. Usually 10 to 20 minutes after the application of a liquid vesicant to the hair there is an erection of the hair coat in the vicinity of the drop. This phenomenon persists for 1 hour or longer and may be important in diagnosis. Two or more hours after contamination, edema of the underlying tissue appears and may increase for 24 hours. These signs appear more slowly in cold weather. As the edema subsides, particularly on the body skin, superficial layers may exfoliate. Where contamination has been heavy an eschar forms and later sloughs leaving an area of ulceration. The majority of such burns heal in 6 to 8 weeks, but some may require 14 weeks or longer. When horses and mules traverse ground where droplets of mustard remain, they frequently develop filling edma around their pasterns and fetlock joints. The animal becomes lame. Edema fluid oozes through the skin and accumulates in the hair coat. The skin becomes pulpy and soft. Fissuring and ulceration may occur and be aggravated by motion of the limb. The fine skin of the hollow of the heel is particularly susceptible and infection may be expected. The horny hoof including the frog is sufficiently resistant to mustard as to require no protection. If a horse, mule or dog must pass through a freshly contaminated area its legs should be protected by impermeable leggings, or by a suitable protective ointment.* Pro-

* Protective ointment, M–4, is irritant to an animal's skin.

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tective ointment M–5 may be used for this purpose but when used on the dog it should be removed by washing with gasoline followed immediately with soap and water since it may produce skin irritation. It should be borne in mind that shell holes may contain liquid vesicants for weeks after contamination.

(*b*) The eyes of animals, especially the horse, are more resistant than mans to injury from mustard vapor. Injury is not produced with short exposures to field concentrations. However, serious eye injury may follow severe exposure. Droplets in the eye cause conjunctivitis, keratitis, and temporary blindness or necrosis of the cornea with permanent opacity. Eye shields which need not be airtight give horses sufficient protection against liquid vesicants. The dog's eye is less resistant than the horse's to mustard vapor. The dog gas mask protects the eyes.

(*c*) Under ordinary field conditions severe exposure to mustard vapor is necessary to cause respiratory tract injury in horses. Here again the dog is more susceptible. Edema, necrosis, and ulceration of the mucous membranes of the respiratory tract follow inhalation of fine mists of mustard in the immediate vicinity of an H shell burst. Signs may appear as early as 10 minutes after exposure. The edema of the air passages often causes an obstructive dyspnea. A bacterial bronchopneumonia may follow.

(d) Contaminated fodder and water, or licking contaminated parts, may produce ulceration and edema of the buccal membranes. When the gastro-intestinal tract is involved, abdominal pain and diarrhea may result.

(*e*) Vapor injury may be severe from the evaporation of liquid mustard on equipment close to the skin.

(2) *Decontamination and treatment.* Because the hair coat of animals impedes penetration, effective prophylactic measures may be instituted later in animals than in man. The healing time is shortened in proportion to the speed with which decontamination is employed and some mitigation of the injury may be expected even after 1 hour. Bleach paste (1 part chlorinated lime in 3 parts of cold water) or calcium hypochlorite (in 8 parts of cold water) should be used to neutralize mustard. This must be worked into the skin carefully avoiding the eyes. Decontaminants are irritant to the animal's skin and should be washed off within 2 to 5 minutes. Decontamination may be accomplished also by vigorous scrubbing of the contaminated area with a 5 percent solution of potassium permanganate. Swabbing with soap and water or with solvents like gasoline and kerosene usually spreads the agent, causing a shallow but larger lesion. When other agents are not available protective ointment M–5, if rubbed into the part, may be used to decontaminate the skin of dogs. Treatment

of vesicant burns will depend upon the severity of the injury and the site oif the lesion. Frequently, sprayed droplets of vesicants remain on the surface of the hair and cause slight superficial skin injury from vaporization. In such instances the droplets should be first wiped away with absorbents to prevent the treatment agents from carrying the liquid into the skin. Since liquid vasicants may remain in the hair for days, decontamination procedures should always be carried out before attempting to treat lesions that have already developed. In treating developed burns, the objectives are cleanliness of the wound and reduction of infection, thereby promoting healing. Cod liver oil ointment, tannic acid, gentian violet (Medical Department item No. 1213500), potassium permanganate (Medical Department item No. 1372200), or other preparations may be of value. Slight injury to skin not exposed to friction of harness and saddlery seldom needs treatment. Eyes contaminated with liquid mustard should be irrigated immediately with water. If the conjunctivae and lids become edematous, bathing with boric acid solution may be of benefit. Pain may be allayed by local anesthetics (1 percent butyn, Medical Department item No. 1108500). Treatment of injuries to the alimentary and respiratory tracts is symptomatic. Prevention of secondary pneumonia should be attempted with one of the sulfonamide drugs. Steam inhalations may provide respiratory relief. Fresh air, warmth, and nursing are essential. Food should be offered from the floor to promote drainage of nasal secretions. Appetizing foods should be given.

c. LEWISITE. (1) *Injury caused by lewisite.* Although the sensitivity of animals is nearly the same to lewisite as to mustard vapor, the lesion produced by liquid lewisite appears earlier and is more severe than that produced by liquid mustard. Lewisite burns resemble those caused by mustard, but are immediately painful and cause restlessness. There may be systemic effects.

(2) *Decontamination and treatment.* Decontamination for the destruction or removal of lewisite must be initiated at the first opportunity. Scrubbing the contaminated skin with a 5 percent solution of potassium permanganate or with bleach as advised for mustard will reduce the injury and lessen the danger of arsenical poisoning. Treatment of the eye, including the use of BAL, is similar to that for man. Late treatment is symptomatic.

d. ETHYLDICHLORARSINE. Injury to the skin by ethyldichlorarsine is less than with lewisite or mustard. Treatment is similar to that for lewisite.

e. NITROGEN MUSTARDS. (1) These agents are less damaging to the skin of animals than equal concentrations of mustard or lewisite. On the respiratory tract their action produces injury of

severity equal to that of mustard. The eyes of the dog and horse may be more susceptible to these vapors than to those of mustard. Injury to the eyes from liquid nitrogen mustards is more severe than from mustard. The treatment of animal casualties should proceed along the general lines advised for mustard. In cases of eye injury, where there is miosis, atropine sulfate (1 percent) should be instilled until mydriasis is induced. The prognosis in contamination of the eye with these agents in the liquid form is serious unless the agent is removed by irrigation with water within 1 or 2 minutes.

(2) Severe exposures, in laboratory animals, result in lesions of the nervous and hemopoisetic systems and in the gastrointestinal tract. (See par. 10*f*.)

(3) Protective devices, especially to guard the eye against liquid spray, are important in prevention of animal casualties from nitrogen mustards. The horse and dog gas masks are effective.

42. Lacrimators and Irritant Smokes

While these agents are intolerable to man in even very low concentrations, under ordinary field conditions they have little effect upon animals, especially horses. Severe irritation may result when a liquid lacrimator gets in the eyes. The treatment is immediate irrigation with water or sodium bicarbonate solution.

43. Screening Smokes

a. WHITE PHOSPHORUS. (1) *Effects.* Burning particles of white phosphorus produce deep burns on contact with the skin. The smoke is nontoxic.

(2) *Treatment.* Smother the burn immediately with water or mud. Keep the burn under water until a 2 to 10 percent copper sulfate solution can be applied. This excludes air by forming a protective metallic coating on the phosphorous particles. The particles can then be removed with forceps or a hemostat. Further treatment is that for ordinary burns.

b. SULFUR TRIOXIDE-CHLORSULFONIC ACID SOLUTIONS (FS). It is believed that this smoke in field concentrations will not affect an animal's skin. Eye burns may follow exposure to irritating concentrations. Water or sodium bicarbonate solution may be used for eye irrigations.

c. TITANIUM TETRACHLORIDE (FM). The liquid may produce burns on the skin and in the eyes, but it is not so irritant as FS. Treatment is the same as for burns caused by FS.

d. HC MIXTURE. Usual field concentrations are not irritating

to animals, but higher concentrations may produce respiratory tract damage like that caused by the lung-irritant gases.

44. Incendiary Agents

Treatment of burns from incendiary agents is that used for any heat burn.

45. Systemic Poisons

a. GENERAL. These are agents which produce their effects after absorption. The most important are hydrocyanic acid, cyanogen chloride, and arsine. Protection requires an efficient type of animal gas mask or collective protector .

b. HYDROCYANIC ACID AND CYANOGEN CHLORIDE. Hydrocyanic acid produces asphyxia of the tissues, especially the central nervous system, and paralyzes the respiratory center. Cyanogen chloride, in addition to producing cyanide effects, irritates mucous membranes and may cause lung edema. Procedure advised in treating human casualties may be used with animal casualties when practical. Dosage of drugs should be adjusted according to weight.

c. ARSINE. For effects of arsine see paragraph 32. Treatment is symptomatic. The animal gas mask gives adequate protection.

46. Incidental Gases

Exposure to incidental gases such as carbon monoxide, nitrous fumes, and ammonia is not expected in the field.

APPENDIX I

A GUIDE FOR THE DISPOSITION OF PERSONNEL WITH BLISTER GAS BURNS

1. Introduction

a. This material will serve as a guide for the use of medical officers in the field in the event they should be confronted with casualties due to blister gases. Its chief purpose is to bring to their attention the current views concerning the casualty-producing powers of blister gases. It will assist the medical officer in the forward area in deciding which type of blister gas case he should evacuate as a casualty, and which type he may retain in the lines without appreciable interference with the fighting effectiveness of the individual. Management and treatment of blister gas injuries have been specifically omitted since they are considered in other sections of this manual.

b. In the years 1917–18 large numbers of allied troops with mustard gas burns were needlessly evacuated from the front lines before the medical officers came to realize the true significance of the lesions and the limitations of their casualty-producing power.

Casualties of World War I

Analysis of 6980 mustard gas cases from World War I showing location of burns)

	Percentage		*Percentage*
Eyes	86	Legs	11
Respiratory Tract	75	Buttocks	10
Scrotum	42	Hands	4
Face	27	Feet	1.5
Anus	24		

c. During the course of World War II, investigations have been made of the influence of blister gas burns on the ability of troops to carry out common types of military duties. In several experimental installations in the U.S.A., Canada, Great Britain and Australia, volunteer soldiers with varying degrees of military service, ranging from recruits with a few months' elementary training to fully trained troops with combat experience, have been burned with blister gas. The degree of disability produced was carefully evaluated on assault courses, route marches, or by simu-

lated combat exercises in the field lasting over a number of days. The observations which were made served to demonstrate the limits of the casualty-producing powers of blister gas and, furthermore, indicated the types of lesions which may or may not cause disability, and have been the basis for this guide, which, however, is not intended to be an adequate substitute for clinical demonstrations of blister gas cases as a means of orientating medical officers in this subject.

d. There are two broad groups of blister gas cases, the disposition of which will offer no problem to the medical officer. In the first group are those who are totally disabled, and who are incapable of either offensive or defensive operations regardless of the seriousness of the military situation. These will be classified as casualties and evacuated as such. Examples of injuries causing total disability are blindness, or vesication of extensive areas of the body, such as an entire limb or the front or back of the trunk. In the second group are those men who have been burned, but whose lesions are trivial and affect their military effectiveness slightly or not at all. They will be classified as noncasualties and returned to the line accordingly, with or without treatment.

e. Between these two groups lies the indeterminate group of the partially disabled men who would be able to carry out certain types of military duties, but would be unable to attempt more strenuous tasks. The disposal of such cases is most likely to present the greatest problem to the medical officer in the field. This guide will draw his attention to typical casualty and noncasualty injuries within this group. In disposing of such cases the medical officer will be influenced by a number of factors, in addition to the severity of the burns, such as the urgency and nature of the military situation, and the physical and mental make-up of the individual under consideration.

f. No effort has been made to differentiate between the injuries produced by the several blister gases which may be used by the enemy. This omission has been made purposely in the interests of simplicity. While there are several points of difference between the typical mustard and arsenical vesicant lesions, it is not recommended that the medical officer, seeing these cases in the field, attempt to dispose of them differently. The diagnostic features of the various blister gases and treatments peculiar to each are described in section III.

2. Eye Injuries

a. The correct disposition of personnel with eye lesions caused by blister gas is less of a problem to the medical officer than when

the skin of the trunk and limbs is involved. A very accurate estimate of the degree of impairment of vision resulting from eye lesions can be made by simple inspection.

b. The eye is more sensitive and more vulnerable to the action of mustard than any other part of the human anatomy. Approximately 85 percent of the mustard casualties in World War I had eye lesions of some degree. Exposure for 2 hours to a concentration of mustard vapor just barely perceptible by odor will produce eye lesions, but may not affect the respiratory tract or skin. There is no immediate symptomatic or local reaction to the absorbed agent; *a latent period* that varies with the degree of exposure precedes the onset of symptoms. The latent period varies from 4 to 12 hours in the case of mild exposures, and may be reduced to 1 to 3 hours after severe exposures.

c. The lesions have been divided into mild, moderate and severe. (See par. 9*b*(1) (*b*)*3* and *4*.)

(1) *Mild* (*75 percent cases in World War I.*) The first symptoms include itching, lacrimation, a sensation of grit in the eye, followed by burning and sometimes photophobia. There is hyperemia of both the palpebral and bulbar conjunctivae, the reaction in the latter usually beginning as a band-shaped area running transversely across the eye, with normal white bulbar conjunctiva above and below it. Edema of the lids may also be present. Hospitalization is seldom required, and recovery takes place in 1 to 2 weeks without classifying the soldier as a casualty.

(2) *Moderate.* In this group there is complete closure of the eyes resulting from a combination of spasm and swelling of the lids. There is a latent period of 3 to 6 hours following exposure. Burning, itching, lacrimation, grittiness, pain and photophobia are more severe than after mild exposures, and *blepharospasm* and blurring of vision are present. There are marked hyperemia and edema of the conjunctiva with a prominent interpalpebral band, edema of the lids, mild iritis, edema of the epithelium of the cornea, producing a roughened appearance like orange peel, although the stroma may be normal. The blepharospasm and edema of the lids may be so severe that the patient cannot open his eyes, and may even believe himself blind. Miosis is present early. A muco-serous discharge is usually present, and although sterile in the early stages, it may cause the lids to stick together, causing accumulation of secretions in the conjunctival sac and predispose to infection. Since cases presenting this picture are temporarily blind they will be evacuated as casualties. Early and prolonged hospitalization is required with transfer to the care of an ophthalmologist if possible. Recovery from these lesions occurs in 1 to 6 weeks, and there is usually no visual loss.

Return to duty has to be determined by the extent of corneal injury, photophobia and blepharospasm.

(3) *Severe.* The latent period is short, lasting from 1 to 3 hours. There is deep ocular pain and headache, both of which may be severe, in addition to severe blepharospasm and blurred or dimmed vision. There is marked hyperemia and edema of the conjunctiva with a blanched area of ischemic necrosis in the interpalpebral portion, chemosis, and edema of the lids, which the patient cannot open. The epithelium and stroma of the cornea are damaged. Early surface epithelium is hazy, and will stain extensively or in a punctuate manner with flurescein within 24 hours. After 24 to 48 hours there is also edema of the stroma of the cornea and a deeper haze becomes apparent. Iritis and a mucoserous discharge are also present. If progressive, there may be dense corneal opacification, with deep ulceration and vascu-

Figure 1. Casualty.

Twelve hours previously this man was exposed to mustard gas vapor without a gas mask. At the time of photographing, his eyes were closed completely, but he made an effort to open the lids as shown by the contracted skin on the forehead. Photophobia was marked. Lacrination was profuse; tears can be seen between the lids. The conjunctivae were injected and the eyelids slightly swollen and congested.

Rhinitis was also present, the man complaining of symptoms of a "cold in the head."

A few days later cough became troublesome and he developed aphonia.

Within 10 days the eye condition had subsided. The cough lasted for a week longer.

This man was classified as a casualty because of the marked interference with vision caused by blepharospasm and photophobia.

Figure 2. Casualty.

Twelve hours previously this man was exposed to mustard gas vapor.

At the time of photographing, blepharospasm was marked and he was experiencing considerable discomfort on moving the eyes. For a period of 4 days he was unable to separate the lids voluntarily. On forcing the lids apart with the fingers the conjunctivae were seen to be injected and the corneas were slightly hazy.

Neither lacrimation nor swelling of the lids was a prominent feature of this case.

larization from the limbus. The cases with corneal ulcers heal slowly and may have relapses. Some may have perforations into the anterior chamber. These cases require hospital care, and should be evacuated at the earliest possible moment.

d. Droplets of liquid blister gas entering the eye may produce similar effects except that one eye alone may be involved or one eye may be affected more severely than the other. Droplets of lewisite in the eyes, in contrast to droplets of mustard, cause immediate and painful spasm of the lids.

e. In deciding the disposition of eye patients, the medical officer must assure himself that mild symptoms are not merely the early evidence of what will develop to severe inflammation, with temporary blindness within a few hours or a day. Reference to the time of exposure to the gas and rate of development of symptoms will guide him as to the course he should take. If the exposure occured within the previous few hours, and the effects are increasing rapidly in severity, it is advisable to evacuate the case as a casualty in anticipation of the development of disabling effects

within the next few hours. As a general rule it can be stated that the symptoms will reach a maximum within 6 to 12 hours.

3. Respiratory Effects

a. The local action produced by mustard, vapor, on the skin and eyes is matched by a similar necrotising action on the mucous membranes of the respiratory tract. Most of the inhaled vapor is absorbed or removed in the large respiratory passages and bronchi and very little injury to the lung parenchyma results.

b. The most common respiratory lesions are due to prolonged exposure to relatively low concentrations of the vapor. In addition, severe casualties may result from men unknowingly exposing themselves to strong concentrations of mustard vapor, because of the fatiguing effect of even low vapor concentrations on the olfactory organs, which may follow after only a few minutes exposure. More severe lesions can be expected, however, in those unable to mask, for example, unconscious casualties, or those with severe injuries to the face and both hands.

c. Lesions of the respiratory tract are characterized by a relatively long latent period before the onset of symptoms; usually 18 to 36 hours intervene between exposure and symptoms. Since the eye is much more sensitive to the agent, and is exposed simultaneously with the nares, respiratory tract lesions should be expected to follow all definite eye lesions, as well as vapor burns of the face in unmasked personnel. *Regard vapor burns of the face and eyes as precursors of lesions in the respiratory tract.*

d. In the nose, the first visible effect is hyperemia of the mucosa, and congestion of the submucosal blood vessels. This is followed by degenerative changes in the epitheliuin, varying with the degree of exposure, from small focal ulcerations to large sloughing ulcerated areas. Nasal symptoms consist of an early and profuse thin mucopurulent discharge. Epistaxis is rare. Nasal injury seldom occurs alone, and if it does, it is not usually a cause for hospitalization.

e. In the pharynx acute inflammation usually appears 1 to 3 days after exposure to mustard vapor although there may be a delay of a week in moderate and mild cases. There is mild dryness and soreness of the throat, aggravated by swallowing, and rarely accompanied by regional lymphatic enlargement, unless secondary infection develops. Pharyngeal and laryngeal lesions may develop without significant nasal involvement, especially in mouth breathers. Upon inspection, the palate, uvula, tonsils and pharynx, are engorged. Multiple white ulcerations may follow. They vary in size depending on the severity of the

exposure. Pharyngeal injury, like nasal involvement, is unlikely to occur alone; if it does, casualty status is not warranted.

f. Laryngeal involvement is especially common as a result of inhaling mustard vapor, the lesions resembling those of the pharynx. Hoarseness, sometimes progressing to aphonia, may last 3 weeks, rarely even longer. This lesion although not likely to require hospitalization, is almost invariably associated with other injuries to the respiratory tract.

g. In the trachea and bronchi, depending on the dosage, a similar ulcerative and necrotizing inflammatory process in the mucosa follows contact with mustard vapor. The exudative results in the formation of a pseudo-diphtheritic membrane in the larynx, trachea, and large bronchi, which is fairly thick and tenacious. It may form a more or less complete cast of the lumen of the structures involved. This lesion may prove fatal, and requires early and prolonged hospitalization. In mild cases, however, small focal ulcerations occur, with hyperemia of the lining epithelium, submucosal edema and congestion, and an outpouring of mucus. Respiratory symptoms and signs suggestive of these lesions, for example, respiratory embarrassment, cough, tachypnea or cyanosis warrant prompt hospitalization.

h. The action of mustard on the lung parenchyna itself is usually insignificant. Secondary infection in the bronchi or alveoli may lead to lobular, or lobar consolidation, and the course, symptoms, signs, and pathologic findings may then be dominated by the characteristics of the type of pneumonia. The initial injury due to mustard in no way affects the choice of standard antibacterial preparations to combat organisms that may be the cause of the secondary infection.

4. Cutaneous Injury

a. INTRODUCTION. (1) Many attempts have been made to formulate clear-cut criteria which will enable medical officers to dispose correctly of personnel reporting with blister gas burns. Experience in field trials at experimental installations has shown that no rigid rules or criteria can be defined which can act as a casualty yard-stick. The most that can be done is to note the types and sites of lesions which have most frequently led to disablement in troops who were exposed to blister gas in field trials, and who subsequently took part in simulated combat exercises, obstacle courses, marches or the like. From these observations the following facts have emerged and are summarized in (2) below.

(2) *Results of observation.* (*a*) Widespread vesication of the trunk makes a man a casualty.

(*b*) Localized vesication makes a man a casualty, if it is situ-

Figure 3. Noncasualty.

A single discrete lesion such as that shown in this photograph is of noncasualty significance because it does not interfere with locomotion; a protective dressing, which will remain in position during exercise, can be applied to a lesion of this size.

Large areas of intense erythema involving the buttocks require the application of a protective dressing. Friction of the clothing can easily break down the injured skin leaving raw excoriated areas of tissue exposed.

The subject of this photograph had additional severe lesions on the trunk which warranted a classification of casualty (fig. 11). This single lesion of itself is not of casualty significance and if it existed alone, the man could continue with his duties.

ated in certain vulnerable areas of the body. Localized vesication in nonvulnerable areas is not of casualty significance, if the lesions can be satisfactory protected to allow the man to continue with his duties.

(*c*) Burns, when produced by high dosages of vapor on masked troops and especially in tropical climates are of casualty severity partly on account of changes brought about in the skin (edema and vesication), and partly the result of constitutional reactions which accompany the skin changes such as nausea, vomiting, collapse and prostration.

(*d*) Burns produced by low dosages of vapor, while sufficient to bring about skin reactions such as edema and subjective symp-

toms (burning and itching) are not usually of casualty severity.

(*e*) When classifying a case as a casualty or non-casualty, the stage of development of the lesion must be taken into consideration.

b. TRUNK AND NECK. (1) *Extensive vesication of trunk.* All the cases considered under this heading should be evacuated promptly as casualties.

(*a*) By extensive vesication is meant numbers of vesicles distributed over the greater portion of one aspect, anterior or posterior, of the trunk. Under such circumstances the intervening area of skin will be involved by more or less severe erythema and pinpoint vesication (figs. 10, 12, and 13). Vesication of this type is likely to occur more frequently on the back of the trunk than on the front. (Possible reasons for this distribution are the pro-

Figure 4. Noncasualty.

This photograph shows mustard blisters localized to a comparatively confined area.

Cases of this type are classified as noncasualties (figs. 5 and 6). With the application of a protective dressing full duties can be resumed.

Figure 5. Noncasualty.

Blisters in this location can be treated and a dressing applied which will allow the man to continue with his duties.

Two days before this photograph was taken this man was contaminated by mustard gas. Twenty-four hours after contamination, the small of the back was covered by erythema, which progressed to vesication by the following day. After that time, the lesions began to subside.

tection afforded to the front of the trunk by webbing, ammunition pouches, etc., and the fact that the front of the uniform does not cling tightly to the body).

(*b*) Extensive vesication may be associated with constitutional effects such as fever, nausea and vomiting. These effects tend to occur more readily in tropical than in temperate climates.

(*c*) Secondary bacterial infection may complicate the course of the lesion at any stage. The medical officer in a forward position

is not likely to see infection of large vesicated areas since such cases will have been evacuated to the rear medical services within the first day or two after contamination, that is before secondary infection is likely to have developed.

(2) *Localized vesication of trunk.* (*a*) Vesication occurring within or adjacent to the natal cleft (between the buttocks) usually calls for evacuation to the base medical services. Walking becomes increasingly difficult. Defecation is painful, and dressings require frequent changing. The lesion is usually most intense at the upper end of the natal cleft and may extend outwards over the buttocks and downwards along the walls of the cleft (figs. 7 and 8). Severe vesication of the buttocks involving the natal cleft is usually due to sitting on heavily contaminated ground, or for prolonged periods on contaminated trousers (fig. 8). Under these circumstances the vesicated area is frequently seen to

Figure 6. ① *Noncasualty.*

These men were exposed to a low concentration of mustard vapor. They had previously been exposed on a number of occasions to low dosages which produced no visible effects. Close inspection of the photographs will reveal the morbilliform rash characteristic of reactions of sensitized individuals.

Figure 6. ② *Noncasualty*

extend forwards across the perineum to involve the scrotum and the penis.

(*b*) Trivial burns such as mild erythema affecting the natal cleft are not of casualty severity, but require careful attention since walking or running easily aggravates these lesions, may break down injured skin, and leave excoriated areas and small intractable ulcers. Small discrete blisters may also be considered in this light but, when the blister gas encountered is mustard, vesication occurs as only part of more extensive lesions consisting of intense erythema and edema of the tissues, and such cases should be classified as casualties.

(*c*) Single discrete blisters on the buttocks avoiding the natal cleft can be classified as noncasualties (fig. 3).

(*d*) The majority of blisters on the trunk will require some form of protective dressing. Otherwise the blister roof will be torn off exposing the raw, sensitive floor to the friction of the

clothing. The secretions tend to cause the clothing to stick to the blister floor, predisposing towards infection. In disposing of blister gas burns, the medical officer must decide whether or not it will be possible to apply protective dressings which will remain in position during active exercises.

(*e*) Examples of vesication on areas where permanent dressings are difficult to apply are shown in figures 9 and 11.

(*f*) Blister gas burns of the trunk which may be considered as noncasualty severity are illustrated in figures 4, 5, and 6.

(3) *Burns caused by exposure to high dosages of blister gas vapor.* After exposure to a high dosage of mustard gas vapor,

Figure 7. Casualty.

The case shown in this photograph was contaminated by liquid mustard on the previous day. There is an old scar on the loin not related to the present condition.

Figure 8. Casualty.

This photograph shows extremely severe vesication of the entire surface of the buttocks. The upper half of the natal cleft was occupied by large coalesing blisters. The vesicated area extended across the perineum to the penis and scrotum which were severely affected.

This man was contaminated heavily by liquid mustard on the trousers. After contamination he sat down for a number of hours, thereby pressing the contaminated clothing into the skin and allowing the vapor to pass upwards towards the perineum.

The photograph was taken 24 hours after exposure. The lesions continued to develop for 2 to 3 days. This man had a high fever for 4 days. He had nausea, anorexia, and suffered considerable mental distress through pain, insomnia, and the fear that the genital region had been permanently injured. He was detained in the hospital for 4 weeks.

especially under tropical conditions, nausea, vomiting, and early symptoms of collapse, are usually evident before the erythema on the skin is completely developed. It is important to note that these effects occur even amongst troops who wear masks during the period of exposure to the gas. Since these constitutional symptoms may persist on and off for several days, during which

the skin burns will be increasing in intensity, cases of this type should be classified as casualties. Severe vapor burns of the trunk appear as generalized vivid erythema (fig. 14) with pale gray areas indicating sites which will eventually vesicate or become necrotic. It is common to see patches of skin where erythema is absent or mild. These represent areas where the clothing was pressed in close apposition to the skin, for instance by a gas mask carrier.

(4) *Burns caused by exposure to low dosages of blister gas vapor.* (*a*) Mild vapor burns, while causing erythema, itching and irritation, are not casualty producing.

(*b*) It is to be noted again that the medical officer should always consider the interval after exposure in relation to the severity of the burns, since a case which presents itself with appar-

Figure 9. Casualty

An area of vasication extended around one side of the neck from back to front. This condition was caused by a splash of liquid mustard which contaminated the blouse.

It was found difficult to apply a protective dressing which would allow the man to carry on with his duties, including the wearing of his equipment. Without a dressing, the blister roof would be easily torn off, the blister floor repeatedly irritated by the friction of the clothing and healing would be delayed. Such a lesion would bring about a state of partial incapacitation. On these grounds cases of this type should be classified as casualties.

Figure 10. Casualty.

Vesication of this extent is of casualty severity. Frequently a rise in temperature occurs. Nausea and vomiting may be present and add to the incapacitation caused by the burns.

These blisters were produced as a result of heavy liquid mustard which contaminated the uniform over the back. No decontamination measures were applied. The uniform was worn for 4 hours after exposure to the agent.

ently mild burns may in fact be showing the early effects of a severe exposure to a vesicant vapor. It will not always be possible to determine the period which has elapsed since exposure to the gas, but an effort should be made to do so. Factors that will

Figure 11. Casualty.

This case was classified as a casualty. Extensive areas of sharp erythema with poinpoint vesication were present within 24 hours of exposure to the agent. The photograph shows the extent of these areas 48 hours after contamination.

Vesicated areas over the scapular region and the buttock require protection from the friction of the clothes and the pressure of equipment. Erythema with beginning vesication should also be protected by a dressing, otherwise the affected skin tends to break down and the vesicated area to spread. It is difficult to apply, and retain in position, dressings which would protect areas of the extent shown here.

Figure 12. Casualty.

The greater portion of the back was vesicated. This man had a temperature of 100° to 101°F. for a few days. He was apathetic, depressed, nauseated, and lost his appetite for 5 to 6 days.

These lesions were produced by mustard sprayed from an airplane 2 days prior to this photograph. After contamination he wore his uniform for 4 hours. At the end of that time, patches of diffuse erythema had appeared on the shoulders. Twenty-four hours after exposure to the agent, the erythema was associated with swelling of the skin and pinpoint vesication.

In deciding the disposition of a case of this type, special note should be made of the rapid increase in severity of the lesion over the first 24-hour period after contamination.

help the medical officer to substantiate his decisions are the rapidity of development of effects and the presence of constitutional effects.

(5) *Sensitization due to multiple exposures to mustard gas.* (*a*) Attention should be paid to the characteristic appearance of 're-exposure" mustard gas burns, occurring in individuals who have been exposed to mustard gas 1 to 3 weeks (or more) previously. A small percentage of men who have been exposed more than once will become sensitized to the agent. Such individuals react differently both qualitatively and quantitatively.

(*b*) A sensitized man will usually show the effects of re-ex-

Figure 13. Casualty.

Widespread vesication caused by mustard extended from the shoulders to the buttocks. The skin between the vesicles was erythematous and edematous, and in many parts showed pinpoint vesication.

Severe discomfort, caused by stretching of the skin, accompanies lesions of this type. In addition, increase in temperature, nausea and vomiting are common, especially in tropical climates.

Burns of this severity, uncomplicated by secondary infection, require treatment in hospital for at least 3 to 4 weeks followed by a period of convalescence.

Figure 14. Casualty.

Twenty-four hours before this photograph was taken this man, wearing a gas mask and protective shorts was exposed to a high dosage of mustard vapor in a warm climate.

Within 6 hours he became a casualty on account of nausea and vomiting, as well as generalized erythema involving the upper part of the trunk and upper limbs. The gastric symptoms persisted on and off for 2 days.

During the ensuing 2 days the erythema continued to increase in severity, deepen in color and break out in pin-point vesication at scattered areas. The axillae and flexures of the elbows were especially affected.

Such cases are classified as casualties soon after exposure.

posure by a rapid onset of symptoms. Erythema, with or without edema and pronounced itching and burning, usually appears within one hour of exposure. Furthermore, less mustard vapor is required to produce effects in a sensitized individual than would be the case in a non-sensitized man. If the erythema and edema are the result of exposure to a low dosage of mustard vapor, they will generally develop rapidly, and subside within 2 to 3 days. If vesication occurs, however, the time required for healing is no less than that in non-sensitized men.

(*c*) One of the most frequent occurrences in sensitized men who have been re-exposed is the development of a morbilliform rash. Such a case is illustrated in figure 6 ① and 6 ②. Another characteristic reaction is an eczematoid dermatitis, surrounding any old burns, whether or not they have healed completely. Such a dermatitis may last for several days; it can best be compared with dematitis venenata (poison ivy). Usually this type of reaction subsides within 48 to 72 hours after the individual is removed from the source of mustard vapor. Similar sensitization phenomena have been known to occur with lewisite and with the nitrogen mustards.

c. ARMS. (1) In a large proportion of the cases of blister gas injuries on the arm, the use of the limbs is not materially impaired, and when suitably treated, the individual is able to continue with all his duties. Vesication, when localized (figs. 15 and 16) will produce little or no disability.

(2) Extensive vesication involving the axillae or the volar or dorsal aspects of the elbow frequently results in partial disablement, by impairing the movement of the limb at these points. Severe burns are most frequently associated with edema of the surrounding tissues which tends to immobilize further the movements of the limbs. The dorsal aspect of the elbow and forearm are common sites of severe burns since these areas, together with the knees, are points of pressure supporting the body when the individual drops prone on the contaminated ground and fires his shoulder arms from this position. The clothing covering these sites is thereby pressed into the ground, and tends to pick up contamination in these areas. Typical lesions produced in this manner are shown in figures 17 and 19. In each case severe edema was present together with widespread areas of vesication. Although the limb could be bent, such movements were painful. Cases of this type should be evaluated as casualties when the lines of communication are normal.

(3) Widespread vesication of the arms is usually associated with

intense local reaction, both factors combining to produce a state of partial disability. Unless the urgency of the military situation will not permit, cases of this type should be evacuated as casualties.

d. THE HANDS. (1) Medical officers may expect to encounter frequently blister gas burns of the hands. In general, burns affecting the hands tend to cause a degree of incapacitation out of proportion to the size of the lesions. Considerable care and judgment is called for in the correct disposition of such cases.

(2) Experience in tropical experimental installations indicates that, while adequate protection against high dosages of vapor can be provided by impregnated gloves and anti-gas ointment, it is diffi-

Figure 15. Noncasualty.

These blisters were produced by liquid mustard gas through clothing. Contamination occurred 1 day previously.

The blisters were discrete and surrounded by an area of erythema with slight swelling of the tissues. When a protective dressing was applied, the man was able to continue with all his duties.

As a rule blisters involving the bends of the limb tend to incapacitate more easily than similarly sized lesions elsewhere on the limb, because of aggravation and retardation of healing resulting from the constant movements of the joints. Blisters of the size shown here are of themselves not casualty producing. More extensive vesication in this area would have interfered seriously with the use of the limb and necessitated the individual's being classified as a casualty.

Figure 16. Noncasualty.

These blisters were produced by liquid mustard gas which contaminated the uniform worn by the man 2 days previously. He discarded his contaminated clothing after 4 hours' wear.

A lesion of this size is associated with edema of the tissues in the neighborhood of the blister. In some cases the edema involves the entire circumference of the limb, and may spread upward toward the elbow or downward toward the hands. A severe local reaction of that type would make a limb virtually unusable, and warrant a classification of casualty.

Under tropical conditions lesions produced through clothing by liquid mustard gas may be expected to increase in severity for 2 to 3 days after contamination. Under temperate weather conditions the lesions are later in appearing, and slower in developing to full maturity.

cult to avoid burns of the hands due to liquid blister gas, especially in heavily contaminated jungle.

(3) The palms of the hands are resistant to vesication. However, if sufficient amounts of liquid agent come in contact with the palms, directly or through gloves or ointment, vesication can occur (fig. 20). Blisters affecting the palms are characteristically painful and slow to heal. When the integument is removed a raw tender surface is exposed and epithelialization is slow.

(4) If the lesion is single and of limited extent (fig. 20), with suitable treatment and the application of a protective dressing, little or no disablement may result.

(5) Burns produced by a liquid agent on the dorsum of the hand result in a severe local reaction characterized by intense edema of the tissues of the back of the hands and of the fingers. Pain is a

Figure 17. Casualty.

The left forearm shows the effects of wearing for 4 hours a Herringbone twill jacket contaminated with liquid mustard gas. This man fell prone onto contaminated ground in the jungle, crawled a few yards, and fired a rifle from this position.

Exposure occurred 2 days prior to photographing the lesions. The elbow and upper third of the dorsal aspect of the left forearm were involved by a deep burn which was pale with incipient necrosis in the center and vesicated at the periphery. Edema involved the circumference of the elbow and the upper two-thirds of the forearm. The limb could be moved at the elbow but movements were painful and resisted by the soldier. Lesions of this type and severity are of casualty significance for 2 or 3 weeks' duration.

characteristic feature of such lesions, and is intensified by any movement of the fingers or wrist. In this way a state of partial disablement is brought about. Burns of this type impair the ability of the individual to carry out any but the crudest actions of the fingers and hands (figs. 21 and 22). Such cases should be regarded as casualties.

(6) In deciding the disposition of blister gas cases, the medical officer should remember that the lesions continue to increase in severity until the second or third day after exposure. Consequently when seeing cases exposed within the previous 24 hours, he should try to anticipate the condition of the lesion within the following day or two. In the case of the hands an individual exposed within the previous 24 hours and reporting for treatment with apparently trivial blisters on the hands may be totally incapacitated the following day (fig. 21). As a working rule, it may be stated that

when an individual exposed to a vesicant, liquid or vapor, within the previous 12 to 24 hours shows sharp erythema of the dorsum of the hand with commencing vesication, it may be assumed that the lesion will progress within the next day or two to the extent that all the erythematous area will become vesicated. If this is extensive, (for example, involving half the hand or more) edema of the tissues will be also present. Under such circumstances, the individual should be evacuated as a casualty when first seen. If the

Figure 18. Casualty.

This photograph was taken 24 hours after the man was contaminated by liquid mustard while going through freshly contaminated undergrowth. He was wearing impregnated clothing, which was removed 4 hours after he became contaminated. The "doughnut" or ring-shaped area of blisters which surround a gray necrotic area at the elbow is a clear example of a severe burn which will require from 2 to 4 weeks to heal satisfactorily.

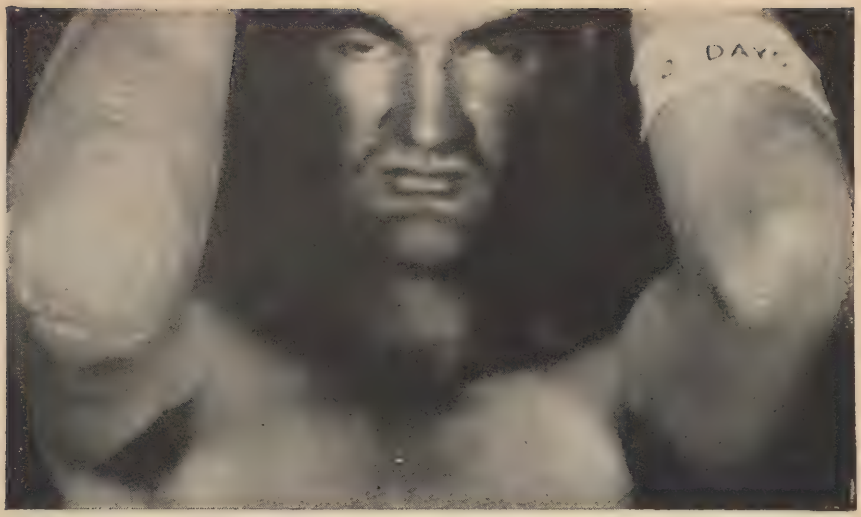


Figure 19. Casualty.

This photograph was taken 2 days after exposure to mustard. The soldier fired a rifle while lying on mustard contaminated jungle floor. As in the cases shown in figures 17 and 18, he wore his contaminated clothing for four hours.

The pale center of the annular vesicle involving the right elbow indicates a deep burn, the center portion of which will eventually become necrotic leaving a slowly healing wound. Severe edema involves the forearm.

After 2 weeks the limb was still swollen and the lesions had not yet healed.

Blister gas burns of this type and position make a man a casualty for about 3 to 4 weeks. If secondary bacterial infection occurs, the healing time will be considerably lengthened.

examination is made 48 hours or more after the exposure the lesion may be considered to be maximal in size.

(7) More frequently the lesions will consist of a number of scattered small vesicles and limited areas of erythema. These cases can be treated satisfactorily, and the individual returned to his duties, the main requirement being protection of the tender area by means of a suitable covering.

(8) Exposure to vesicant vapor produces diffuse erythema involving the dorsum of the hand and wrist. With low dosages of vapor the condition does not proceed beyond erythema. High dosages cause generalized sharp erythema, edema of the tissues and vesication of the dorsum of the hand and fingers. In severe cases of this type, pinpoint vesication involves the entire dorsum of the hand and fingers, thereby totally disabling the hands. These cases will be evacuated as casualties.

e. LOWER EXTREMITIES. (1) The most common sites of development of liquid blister gas burns on the lower extremities are the knees. This site, together with the ankles, frequently contains le-

sions which result in incapacitation of the individual by interfering with locomotion. Movements of the limb at the joints tend to aggravate existing lesions by increasing local edema. A further incapacitating factor is introduced by the discomfort attending the application and wearing of firm dressings to the points of maximum movement of the lower limb.

(2) It has been mentioned under "Arms" that when an indi-

Figure 20. Noncasualty.

The palm of the hand is resistant to vesication. Prolonged contact with liquid vesicant agent is necessary to produce blisters on this area. The photograph shows a hand on which a glove contaminated with liquid mustard gas was worn for 4 hours. Exposure occurred 2 days prior to the photograph. The blister was treated, a protective dressing applied, and the soldier continued with his duties.

Blisters on the palm of the hand are painful. If denuded, a raw tender area is exposed which is slow to heal; consequently, a protective dressing is necessary.

In the present case the soldier experienced discomfort for several days in handling objects, but discomfort alone is not usually regarded as a casualty producing factor.

Figure 21. Casualty.

The dorsum and fingers of each hand were vesicated. The remainder of the skin was erythematous, and the tissues markedly edmatous especially on the left hand. The hands were virtually useless and the individual was classified a casualty.

Pain of a burning and throbbing nature sufficient to prevent sleep for a few days is a prominent feature of severe blister gas burns of the hands.

Two days previously this man crossed an area of jungle contaminated with liquid mustard gas. Even though his hands were covered by impregnated gloves worn over antigas ointment, he picked up sufficient mustard on his gloves to cause burns like these.

vidual is compelled to fall prone onto the ground in a contaminated area, the elbows and knees become points of pressure, and lesions tend to develop on these sites with greater frequency than elsewhere. Vesication frequently spreads over the kneecaps, upward on the thighs, and downward on the legs. These burns tend to be extensive and deep, and are frequently associated with edema. Edema involves not only the immediate site of the burns, but often extends as high as half way up on the thigh and half way down the leg (fig. 28). In view of the interference with locomotion, the pain caused by movements of the limbs and the tendency of such lesions toward delayed healing, it will be advisable for medical officers to evacuate as casualties all cases presenting these appearances.

(3) In general, burns of the leg are more incapacitating than burns of the thigh. This is especially true of the calf of the leg, the pretibial area, and the ankle.

(4) It has been shown in simulated combat exercises in experimental installations that in many cases the presence of numbers of superficial blisters on the legs and thighs alone are not sufficient

Figure 22. Casualty.

Blister gas burns of this severity are always of casualty significance.

This photograph was taken 48 hours after the exposure, the lesions having reached full maturity by that time. The dorsum of the hand was grossly erythematous and the ulnar half was occupied by a large blister. The dorsum of each finger was vesicated and the skin stretched tight with edema.

In addition there were six discrete blisters on the palm of the hand, an area which is resistant to vesication except by prolonged contact with liquid mustard gas.

The hand was tender to touch, pain was severe and was of a throbbing nature accentuated by holding the hand in the dependent position. This soldier required 4 weeks' hospital treatment before the lesions were sufficiently healed to allow him to return to his duties.

to render a man incapable of carrying out normal military duties. The type of case referred to is illustrated in figures 23, 24, 25, and 26. With suitable dressings, troops with lesions such as these were able to take part in daily marches, gun drill, or similar activities. In disposing of cases with lesions of this type and extent, in addition to the clinical findings, the medical officer will take into consideration additional factors which should influence his decision, such as the mental and physical make-up of the individual, his willingness to continue with his duties, and the military situation existing at the time. Such cases will fall into the category of partially disabled personnel. After suitable protective dressings have been applied, men with good morale and robust physiques may be returned to duty as noncasualties.

(5) Reference has already been made to the influence of the site of the lesion on the degree of incapacitation. A relatively small blister or group of blisters situated in the popliteal area may reduce significantly the efficiency of a man to the extent that he should be evacuated as a casualty (fig. 29). This is due largely to the interference with locomotion and the aggravation of the lesions by moving the limbs. At the same time it does not follow that any blisters affecting these areas are necessarily casualty producing (fig. 27). Effects, such as local inflammation and edema, the presence of infection, and extent of the lesions on other parts of the body should be borne in mind when deciding the disposition of the individual. In this respect, the available evidence from trials in the field with mustard gas and lewisite indicates that the mustard gas blister, size for size, is potentially more incapacitating than the lewisite blister. The main reason for this is the tendency of the mustard blister to be surrounded by a diffuse area of erythema and edema, while the lewisite blister is usually circumscribed with little local reaction in the neighboring tissues.

(6) A not uncommon site for the development of vesicant lesions is in the vicinity of the ankle at the level of the top of the shoes. A vesicant area frequently circumscribes the limb at the point of least protection between the shoes and the leggings. Such a lesion is associated with severe pain due to circulatory impairment and tense edema of the entire lower limb. Cases of this type should be evacuated as casualties on the grounds that movements of the limb tend to aggravate the severity of the condition, and, in addition to interfering with locomotion, they seriously retard healing.

(7) Vapor burns of legs tend to be aggravated in the popliteal spaces. Pin-point vesication is frequently found in these areas associated with local edema. After exposure to higher dosages intense erythema with scattered area of vesication may be seen over

Figure 23. Noncasualty.

This plate shows a number of blister gas burns on the legs of a man sprayed with mustard gas from an aircraft 2 days previously. He wore his contaminated clothing for 4 hours. When suitably protected by dressings, which may be expected to remain in position during active exercises, the individual may return to full duty.

the entire surface of the leg. While such lesions are invariably of casualty-producing significance, they are in addition always accompanied by severe burns in other parts of the body and frequently with severe systemic effects.

(8) Mild vapor burns of the legs produce the characteristic irritation and itching common to all widespread vapor burns. While such effects are troublesome, they are not of casualty-producing significance, and men so affected should be returned to their duties.

(9) Extensive vesication of the feet is not common. The thick skin of the soles is resistant to vesication. Furthermore it is protected by the sole of the shoe unless this is in bad state of repair. Blister gas burns on the dorsal aspect of the foot are often associated with a sharp local reaction similar to that seen on the backs of the hands. Cases with burns of this type, especially if wide-

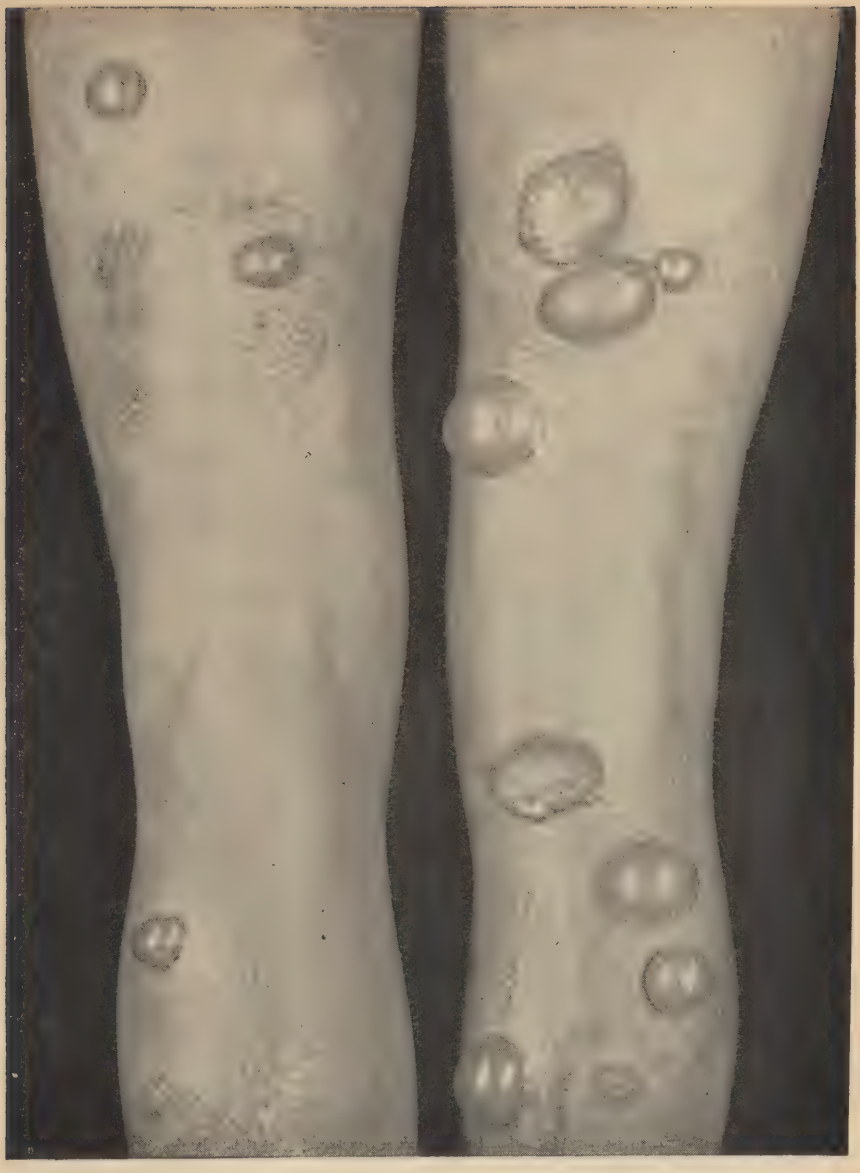


Figure 24. Noncasualty.

A man with vesication of this extent is on the border line of the casualty state. The individual blisters escaped the bends of the knees; therefore, they were not constantly aggravated by the movements of walking or running. Furthermore, the vesicant agent was lewisite, which tends to produce discrete blisters with a narrow zone of erythema in contrast with mustard and which causes a more severe reaction over a wider area around the blister.

This man claimed that he was able to continue with his duties. After the application of a protective dressing he took part in daily route marches or mild duties such as gun drill. The blisters continued to make satisfactory progress during the ensuing 10 days.

spread over the foot, find it difficult or impossible to wear shoes and will require evcuation to the rear medical services. Small discrete blisters may be of noncasualty significance. They may be effectively protected to allow wearing of the shoes and walking with little discomfort.

f. GENITALIA. (1) The genital region is, after the eyes and the respiratory tract, the most sensitive area of the body for blister gas burns. In World War I, many casualties were produced by mustard gas burns of the genitalia. The majority of these burns were caused by mustard vapor. While the present methods of protection against blister gas include special impregnated garments designed to protect the genitalia, when blister gases are employed in chemical warfare, medical officers (especially in tropi-

Figure 25. Non-casualty.

A single vesicle is not necessarily of casualty significance.

The individual whose knee is shown in this photograph sustained a severe lesion just above the knee cap. The local reaction did not seriously interfere with locomotion and after a firm dressing had been applied he was able to continue with his duties.

The importance of the site of a lesion in relation to its incapacitating effects has been referred to previously. A lesion of the type shown in this photograph would be of casualty severity if it were situated in the bend of the knee.

Figure 26. Noncasualty.

This shows erythema and pigmentation of the legs 72 hours after exposure to mustard vapor. There had been superficial vesication of the knees. This man was able to perform all of his duties and to complete an obstacle course without difficulty. The erythema is demarcated at the upper thigh because of impregnated undershorts that were worn during the exposure.

cal theaters of war) may be confronted with a large number of blister gas burns affecting this area.

(2) The most common type of burn affecting the male genitalia is a diffuse vapor burn. Erythema is not conspicuous on account of the normal pigmentation of the penis and scrotum. The most prominent objective feature of the burn is edema which involves the penis and scrotum. Edema fluid accumulates most readily at the prepuce, which becomes markedly distended in its entire circumference, and forms a characteristic semitranslucent ring

around the corona (figs. 30 and 31). In more severe cases the skin covering the entire body of the penis becomes grossly edematous, the external aperture being constricted to pin-point size (fig. 32).

(3) Lesions of this type give rise to greater mental apprehension than physical discomfort although the latter can be considerable. Occasionally, vesication is superimposed on the edematous skin of the penis. Small blisters or ulcers due to break down of the skin are not infrequent at the tip of the prepuce, where they are likely to become secondarily infected and retard healing. With the severe cases associated with marked edema, retention of urine, partly mechanical and partly reflex, may occur.

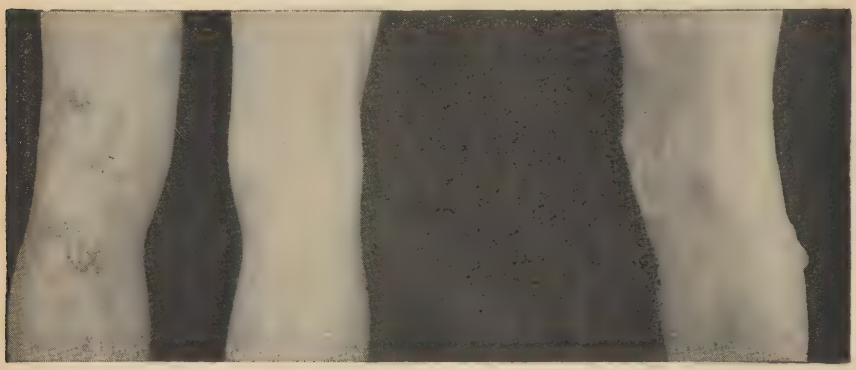


Figure 27. Noncasualty.

Small, discrete and superficial blisters do not necessarily make a man a casualty even though they affect the skin in close proximity to the bend of a limb.

This photograph shows blisters which affected the left leg within a few inches of the bend of the left knee. Each blister was surrounded by a diffuse area of erythema. With a suitable protective dressing this man was able to continue with his duties without impairment of efficiency.

With blisters of this size and distribution, even though treatment were not available, it is not likely that the man would be incapacitated, but he might experience considerable discomfort.

(4) In mild cases objective changes on the scrotum are liable to pass undetected because of the normal pigmentation and the elasticity and looseness of the skin. Edema may be present before sufficient fluid accumulates to reveal its presence. In severe cases the scrotum may become grossly enlarged as a result of edema, to which the tissues in this region are predisposed by the amount of subcutaneous tissue, laxity of the skin, and the dependent position of the organs. The rugae may be partially or completely obliterated (fig. 32). Pin-point vesication may be present. Usually a delay of a few days occurs before it appears. The skin of the

scrotum tends to break down easily leaving small painful ulcers and fissures.

(5) Burning is the most prominent subjective symptom of le-

Figure 28. Casualty.

This picture demonstrates the severe reaction produced by a mustard blister on the lower third of the left thigh. An annular vesicle with a pale parchment-like center is seen to occupy the lower third of the ventral surface of the thigh. This is surrounded by a wide area of erythema which extends downward over the knee and around the circumference of the limb.

This burn was associated with a continuous throbbing pain made worse by walking or any other movement of the limb.

Cases showing this combination of extensive vesication and swelling of the tissues should be regarded as a casualty significance even though only one limb is involved.

This photograph was taken 24 hours after contamination. A reaction as severe as that depicted shows that the individual had been exposed to a severe liquid contamination for a prolonged period. The severity of the burn may be expected to increase during the following day or two.

Figure 29. Casualty.

This photograph was taken 48 hours after the man had been sprayed with mustard gas from an aircraft. He discarded his contaminated clothing after 4 hours wear. Mustard blisters of this type situated in the bends of the limbs are usually of casualty significance, since locomotion is impaired by the pain and discomfort brought about by movements of the joints. Furthermore, prolonged marching or running tends to aggravate the local reaction in the tissues, which is usually an accompaniment of mustard gas burns. This is in contrast with the findings of lewisite burns which are usually circumscribed and accompanied by a more localized reaction in the surrounding tissues.

sions of the genitalia. It increases in intensity as the condition develops. Mental apprehension, anxiety and distress prevail while the objective changes described above are present. As the appearances subside, itching commences and may persist long after the active effects have subsided. Sometimes itching is intolerable. For a considerable period after the lesions have healed, the skin of the scrotum tends to break down, with raw cracks and ulcers which are painful and irritating.

(6) A characteristic feature of the genital region occurring after exposure to low dosages of blister gas is the delay in the development of the effects, frequently 4 to 10 days elapsing before the earliest evidence appears.

(7) Mild cases without edema or vesication, complaining only of subjective irritation and burning may be safely returned to the lines. Some form of anti-irritant lotion is advisable. In disposing of mild cases of blister gas burns of the genitalia, the medical officer must assure himself as best he can that the symptoms are

not in an early stage of development that will mature within a day or so to a severe degree of vesication and edema. He may do so by noting the circumstances of the exposure, the interval since exposure, and the severity of the associated lesions. Severe cases as

Figure 30. Casualty.

Cases presenting this appearance within 24 to 48 hours of the exposure to mustard vapor should be evacuated as casualties. In all cases the edema is likely to increase in amount and in some cases within the following few days will assume massive proportions (fig. 32).

Edema fluid accumulates most readily at the prepuce.

Because of the normal pigmentation of the skin in these areas erythema is rarely conspicuous on the scrotum or penis except after exposure to high dosages. Deepening of the normal pigmentation may be evident after 1 or 2 weeks.

Figure 31. Casualty.

The appearances of the penis 48 hours after exposure to a moderate dosage of mustard vapor are shown in this photograph. Edema had distended the prepuce which formed a translucent ring around the corona.

In addition, edema was present in and beneath the skin of the scrotum. Burning and itching of the parts were troublesome.

Cases presenting these appearances should be evacuated as casualties.

described above should be evacuated as casualties, not only on account of the physical discomfort involved, but also because of the marked mental apprehension from which the individual suffers.

5. Systemic Effects

a. In general it may be considered as probable that severe systemic effects due to the blister gases will be encountered only in the presence of, or antecedent to, disabling skin burns. The medical officer should be familiar with these effects which include anorexia, nausea, vomiting, depression, and fever and are far more likely to be encountered in hot than in cool climates. Malaise and nausea generally initiate the reaction which may then progress to either mild and transient vomiting or to severe and persistent vomiting and retching. In mild reactions anorexia may be the only complaint. The usual time of onset for such symptoms is from 4 to 12 hours after exposure and often occurs before skin injury is manifest. No rule can be given from the duration of these symptoms, although men have usually recovered for the severe gastric dis-

turbances (vomiting) within 24 to 36 hours. Anorexia and nausea may persist over a longer period of time.

b. The temperature may remain elevated for several days. Mental depression may follow mustard burns and persist for several days after exposure.

c. Since men with systemic reactions will probably be casualties, not only because of these symptoms, but also because of extensive skin burns, such cases should be evacuated without hesitation as soon as facilities permit.

6. Secondary Bacterial Infection in Blister Gas Injuries

a. This section deals with secondary bacterial infection of blister gas injuries, so far as it influences the disposition of the affected personnel by the medical officer in forward positions. For the management and treatment of such cases, see section III.

b. Secondary bacterial infection has frequently been cited as a common complication of mustard injuries of the skin. While these injuries sustained in the field are exposed to the same risk of de-

Figure 32. Casualty.

This photograph shows the effects of exposure to high dosages of mustard vapor.

There was massive edema of the entire penis sufficient to interfere mechanically with micturition. Vesication was present at the end of the penis. The scrotum was generally edematous with pin-point vesication. The rugae were partially obliterated.

Lesions of this type call for evacuation to the hospital where treatment for 4 to 6 weeks is usually required.

veloping sepsis as are thermal and traumatic injuries, observations made at experimental installations in both temperate and tropical climates indicated that the incidence of sepsis in mustard lesions has been remarkably low.

c. When it occurs, secondary infection manifests itself some days after the injury first develops. It is unlikely that forward medical officers will see gross secondary infection of extensive blister gas injuries since these more severe cases will probably have been evacuated as casualties prior to the development of infection. Infected lesions of this type will more probably come to the notice of medical officers in rear medical units.

d. When secondary infection develops in blister gas injuries of noncasualty severity, each case should be judged individually. Infection in small lesions does not compel a man to be evacuated. Infection in multiple lesions which previously allowed a man to continue with his duties is usually an indication for his evacuation as a casualty, particularly if constitutional effects are associated with the local effects of sepsis.

e. Sites in which sepsis tends to be particularly disabling are the feet and hands, the genitals and the flexures of the limbs.

f. In injuries to the respiratory tract caused by blister gas vapor, secondary infection, as in cutaneous lesions, is more likely to occur in severe rather than in mild cases. It is unlikely that the medical officer in forward areas will ever encounter such cases. Severe respiratory tract effects will invariably be associated with eye effects of casualty severity. Such respiratory lesions which may develop will not appear for several days by which time the case will have been evacuated as an eye casualty to a rear medical unit.

g. Secondary infection is uncommon in mild cases of mustard conjunctivitis which ordinarily would allow an individual to continue in the line.

h. With eye effects short of casualty significance, respiratory tract effects, (pharyngitis, laryngitis and tracheitis) may continue to increase in severity for several days. Cases of this type may rarely develop secondary infection (bronchitis and broncho-pneumonia).

GENERAL PRINCIPLES IN THE HANDLING OF CASUALTIES CONTAMINATED BY CHEMICAL WARFARE AGENTS

1. General

All medical installations will be well prepared in advance to receive casualties contaminated with blister gases. Other chemical casualties do not present the problems which arise with the handling of blister gas contaminated casualties, and may therefore move with the regular flow of casualties, *but there should be separate arrangements for the reception and handling of the blister gas contaminated casualties.*

2. Responsibility of Medical Facilities

a. It is the responsibility of each officer and man to carry out personal decontamination for himself or his buddy at the earliest possible moment. Medical personnel will attempt the decontamination of casualties who are unable to carry out personal decontamination but are not to decontaminate personnel who are not casualties.

b. Medical installations are concerned only with casualties, that is, personnel no longer able to carry out their military duties. No other men should be sent to the medical services.

3. Objectives of Medical Facilities

In handling blister gas contaminated casualties, the general objectives desired are:

a. The casualty should be handled in such a manner as to minimize the injury which may result from his chemical exposure, without at the same time significantly aggravating the clinical conditions arising from the associated injury.

b. Litter bearers should be protected from unwarranted chemical injuries as a result of working in contaminated areas and of handling the contaminated wounded.

c. The spread of contamination to other personnel and to the interior of ambulances and inclosed spaces, such as operating rooms and hospital wards should be avoided.

d. Medical facilities must be protected so that normal services, unrelated to chemical casualties, can be carried out.

e. A single method should be instituted for collecting all casual-

ties which is as simple and streamlined as the complicated situation will allow.

4. Decontamination of Wounded

a. If the situation permits and life is not endangered by the delay, personal decontamination of wounded men should be carried out on the spot by the litter bearers, or as soon thereafter as possible. This is desirable since the longer the contamination remains on the body, the more severe are the subsequnt burns, the greater is the danger of the spread of contamination to equipment, blankets and other personnel, and the greater the vapor hazard from casualties in inclosed spaces and ambulances.

b. To complete personal decontamination, which requires time, will prolong exposure and may increase shock. The tactical situation may be such that complete personal decontamination may be impossible. In severe injuries, decontamination will rarely be possible until the immediate surgical condition is attended to, and even then the extent to which it can be done will vary greatly. General guides as to the probable action required are essential to successful training of litter bearers and company aid men. *Litter casualties* will, as a rule, receive little personal decontamination as their injuries will usually be severe. Most *walking casualties* will be less severe and shoud have had personal decontamination. The general principle *"better the blistered living than the decontaminated dead"* should be followed.

c. In general, the following are considered advisable in the order named:

(1) Essential first aid for wounds.

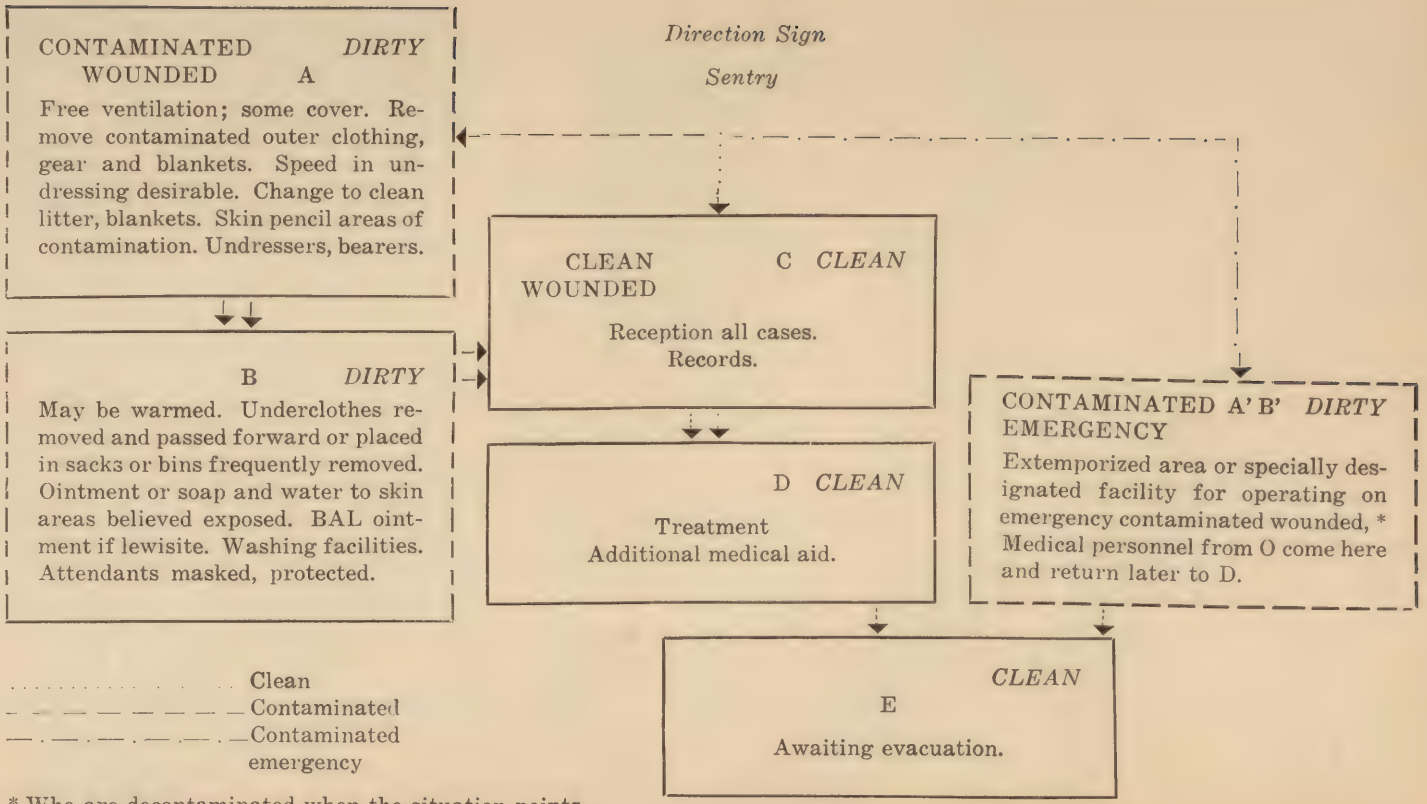
(2) Care of contaminated eyes.

(3) If casualty is required to stay in the contaminated area or to wear contaminated clothing for any time, mask to protect lungs just as soon as rendering of essential first aid permits.

(4) Decontamination of contaminated skin just as soon as essential first aid and protection for lungs (if required) are provided.

5. Reception of Contaminated Casualties (fig. 33)

a. The reception and handling of blister gas contaminated casualties will vary with the type of medical installation receiving them and with the tactical situation. For the reception of such casualties a "dirty" area is required. In that area contaminated casualties will be decontaminated, and thereafter be passed along with the "clean" (uncontaminated) cases. A general principle for the sorting and reception of all casualties including chemical, is indicated in the diagram.



* Who are decontaminated when the situation points.

Figure 33. Basic plan for sorting.

b. Uncontaminated casualties will be admitted directly to the "clean" area (C) to be treated as ordinary medical casualties. Contaminated casualties will be received into "dirty" area (A), there to be decontaminated before being passed into the normal flow of casualties. If requiring special medical aid before personal decontamination, they are received directly into the "dirty" area (A' B') for contaminated emergencies, thus by-passing A, B, C and D. Once emergency is cared for in A' B' the function of A and B, which are not yet completed, are carried out before passing the patient into the flow of clean casualties for evacuation (Area E).

c. Within the "dirty" area, the following will apply:

(1) The arrangements to be made will vary with the location of the unit and the facilities available.

(2) Areas A, B and C need not be adjoining rooms or facilities.

(3) In certain permanent establishments, special provisions may be made. If "cleansing or decontamination centers" have been previously constructed, they should be so employed as to conform to this basic plan.

(4) In temporary camps an existing hut, tent or open shelter may be utilized.

(5) In the field the "dirty" area may be only an area marked out and situated not adjoining, but yet not to far removed from the medical installation. Simple arrangements only are required.

(6) Personnel manning the "dirty" area must be trained in the decontamination of casualties and should be provided with protective aprons, protective gloves and M–5 protective ointment. (See TM 3–220.) The U. S. Army Cover, Protective, Individual can be employed to advantage.

(7) Free ventilation is required, and, if possible, some cover overhead.

d. Detailed Procedure. (1) *Area A.* Here all contaminated outer clothing, equipment, and blankets are removed. *They must not be taken beyond this point.* Speed in undressing casualties requires practice. The casualty is then changed from a contaminated blanket to a clean litter and a clean blanket. If available, a skin pencil can be used to indicate the area of contamination.

(2) *Area B.* This area may be warmed. Here underclothing is removed and placed in bins, sacks or piles, which are frequently removed from the area on the assumption that they are contaminated material. In this area the skin is treated with appropriate ointment, solvent or soap and water. Ointment is preferable if no erythema has appeared. If erythema or blisters are present, use soap and water, except with lewisite cases, who at this point receive BAL ointment if possible. It is desirable to provide washing

facilities so that when expedient a soap and water bath can be given here. Indications for this will vary.

(3) *Area C.* In this area all cases are received. Clean cases are admitted directly; contaminated cases only after going through A and B. Note exception A' B' above, "Contaminated Emergencies."

(4) *Area D.* Special treatments are given in this area, including facilities for soaping and washing off with water.

(5) *Area A' B'.* Here medical personnel come to care for casualties requiring immediate medical and surgical aid more urgently than personal decontamination. Once emergency service is rendered the casualty, personal contamination is completed here. Medical personnel wear gas masks, protective aprons (U. S. Army Cover, Protective, Individual is excellent), and apply M–5 ointment to their hands and carry out personal decontamination before returning to the clean medical facility. It may be an extemporized facility or a designated room set aside for the purpose. It cannot be used later for clean cases, but can be used for similar emergencies. It must be recognized as a contaminated area and respected accordingly.

(6) *Area E.* The casualties are held in this area to await evacuation.

(*a*) A most important need is effcient sorting of casualties in Area A by an officer or a noncommissioned officer. Of nearly as great importance is the supervision of the admittance of casualties to Area C.

(*b*) The personnel employed in Area A, in addition to a well trained soldier for sorting, should be the litter bearers who bring in the casualties. It may be possible to detail extra medical aid men to assist in the activities of this area.

(*c*) In Area B the undressers will be medical department soldiers detailed and trained for the special activity required in this area.

(*d*) A problem of considerable importance is the handling of valuables and personal effects of contaminated casualties. Experience has already shown that what would appear to be a small matter may cause a great deal of trouble. Clothing and equipment removed from the casualty must be searched and small valuables, letters, etc. cared for by suitable means. If contaminated, and then carried with the casualty into an inclosed space, they may create a serious vapor hazard there.

(*e*) Reclothing will be a problem which must be planned for. Fatigue clothing, pajamas or underwear may be available for litter cases. Some clothing and shoes may be obtained from litter cases which have not been contaminated. At hospitals, ordinary hospital clothing is available.

6. Reception of Contaminated Casualties at Rear Zone Installation

a. Reception and handling of chemical casualties at fixed installations in zones well to the rear require certain modifications of the above plan. Two types of contaminated casualties must be expected: those incurred in the vicinity of the installation and probably grossly contaminated, such as would occur with a high explosive bombing followed by chemical attack; and those incurred in a forward area some time earlier, and evacuated after personal decontamination to the hospital for treatment. The latter, are clean cases and present no problem as to reception. The former present a considerable problem.

b. The present problem with regard to reception and handling of chemical casualties at fixed medical establishments is one of *decentralization,* as opposed to the former idea of a single decontamination center for all chemical casualties. *Any plan which permits a line of individuals to await decontamination at a centralized point will result in increasing the degree of injury.*

c. It is essential that contaminated clothing be removed at the earliest opportunity and *that there be available multiple decentralized reception points,* that is, "dirty" areas A and B, and "clean" area C, and that, employing this principle, all blister gas contaminated casualties be segregated from clean casualties, until the former have been properly decontaminated.

d. Blister gas contaminated wounded can, if the plan is properly prepared in advance, be taken from the place of sorting to ward entrances, just forward of which (Area A or Area A-B) clothing will be removed by litter bearers and placed in bins, sacks or piles to await periodical collection by decontamination squad personnel or sentries posted to this duty. Here also valuables will be properly cared for until decontamination can be carried out. If no special entrances facility has been provided, the casualty will be decontaminated just forward of the entrances to the ward, as in Area A–B, and changed to new litter and blanket, then passed just inside the entrance as in Area C. At times it may be necessary to carry out Area B activities just inside ward entrance (in very cold weather). It may be possible to plan for reception of such contaminated casualties via an entrance or facility which is set aside to provide for the procedures normally carried out in Area B of basic plan.

e. At times it may appear to be necessary for certain emergency cases to by-pass all of these various points and go directly to an operating room. *If this is done, it must be remembered that the room and equipment will become contaminated and this must be*

taken care of before subsequent casualties may be cared for therein. From the military standpoint it is undesirable, because of interior contamination, to lose the use of such an important operating facility. IT IS NECESSARY TO HAVE ALTERNATIVE PLANS WHERE THE OPERATING TEAM CAN GO TO AN IMPROVISED OPERATING ROOM TO CARE FOR SUCH EMERGENCIES (AREA A' B'). All personnel handling emergency contaminated casualties must wear gas masks and protective aprons, and should observe personal decontamination with regard to their hands on completion of the emergency operation. Following removal of mask, protective apron and completion of personal decontamination, personnel who have been attending contaminated casualties in such an emergency operating facility may safely return to a clean operating room. The U. S. Army Cover, Protective, Individual serves well as a protective apron.

f. In all medical establishments, therefore, there will be set up a special facility paralleling the operating room, in which contaminated surgical emergencies can be handled. The general principle to be observed is to maintain the normal medical or surgical facilities as free from contamination as possible, employing an alternative facility for the care of such a contaminated emergency casualty.

g. The employment of multiple facilities as opposed to a centralized one is of fundamental importance, even though these facilities may lack something in the way of completeness. The same principle applies to First Aid Stations in areas subject to aerial attack by the enemy.

h. The basic plan and principles to follow are those outlined for Areas A, B, C, D and E. A diversity of plans, employing these principles, is possible providing adequate means are available for handling such contaminated casualties.

i. The planning for the choking gas casualties presents mainly the problem of providing large amounts of oxygen and personnel in adequate numbers with the proper training to administer the oxygen to such cases.

APPENDIX III

MEDICAL DEPARTMENT ITEMS FOR FIRST AID AND TREATMENT OF CHEMICAL WARFARE CASUALTIES

	Med. Dept. Item No.	Item	Unit	Quantity
1.	9776400	Kit, First-Aid, Gas Casualty, Complete Containing:		
	9766300	Container for Kit, First-Aid, Gas Casualty	Each	1
	1069000	Amyl nitrite, 10 ampules	Pkg.	1
	9102800	BAL Ointment, two ¾-oz. tubes	Set	1
	9105000	Calamine lotion, approx. 2-oz.	Bottle	1
	9105800	Chloroform, approx. 2-oz.	Bottle	1
	9107500	Copper sulfate solution, approx. 2-oz. bottle	Set	1
	9109100	Eye and nose drops, ½ oz.	Pkg.	1
	9109525	Eye solution BAL, ½ oz.	Pkg.	1
	9118700	Protective ointment, C.W.S. 3 oz.	Tube	1
	9211800	Pad, cotton approx. 1- by 2-in. 50	Pkg.	1
2.	9776700	Kit, Treatment, Gas Casualty, Complete Containing:		
	9776800	Kit, Treatment, Gas Casualty, container	Each	1
		Section A		
	9102700	Amyl Salicylate, 8 fluid ounces	Can	3
	7493000	Soap, White, Floating	Bar	2
		Section B		
	9104800	Calamine concentrate	Pkg.	2
	9116500	Petrolatum, two 3/5-oz. tubes	Pkg.	2
	9109100	Eye and nose drops	Pkg.	4
	9107500	Copper sulphate solution	Pkg.	1
	9105800	Chloroform	Pkg.	2
		Section C		
	9931000	Kit, Water Testing, Screening	Kit	1
	9118700	Protective ointment, CWS	Pkg.	4
	9120300	Sodium Sulamyd	Pkg.	1
	9116500	Petrolatum, two 3/5-oz. tubes	Pkg.	3
	9911700	Bottle, Plastic, 3½ to 4 fluid oz.	Bottle	1
	9107300	Copper sulphate powder, approx. 37 grams	Bottle	1

	Med. Dept. Item No.	Item	Unit	Quantity
	9116300	Ophthalmic disks, fluourescein and atropine sulphate	Box	1
	9120400	Sulfadiazine tablets	Pkg.	8
		Section D		
	1069000	Amyl nitrite, 5 minim amp: 10	Pkg.	4
	9116500	Petrolatum, two 3/5-oz. tubes	Pkg.	10
		Section E		
	9102800	Bal ointment, two ¾-oz. tubes	Pkg.	6
	9109525	Eye Solution, BAL, ½ oz.	Pkg.	2
	9116500	Petrolatum, two ½ ounce tubes	Pkg.	6
		Section F		
		Pamphlet for use of Medical Officers	Each	1
3.	9775600	Set, Gas Casualty, M2, containing:		
	9778910	Packboard, plywood	Each	1
	9792200	Unit medical equipment pack, empty case	Each	1
	9776700	Kit, Treatment, Gas Casualty, complete	Each	1
	9792300	Unit medical equipment pack, empty insert, 1 each for the following	Each	2
	9903000	Apron, impermeable	Each	3
	9926315	Gloves, impermeable, size 11	Pair	3
4.	9775800	Gas Casualty Case, Aprons and Gloves, containing:		
	9747000	Blanket Set, small, case, empty	Each	1
	9903000	Apron, impermeable	Each	20
	9926305	Gloves, impermeable, size 12	Pair	1
	9926310	Gloves, impermeable, size 11½	Pair	4
	9926315	Gloves, impermeable, size 11	Pair	10
	9926320	Gloves, impermeable, size 10½	Pair	5
5.	1088500	BAL in Oil (Ampule)	Pkg.	10
6.	9815500	Gas Casualty Set, Veterinary, Case, Aprons, complete, containing:		
	9751500	Case, utility, canvas, empty	Each	1
	9903000	Apron, impermeable	Each	8
	9914000	Bucket, canvas, collapsible	Each	4
7.	9815600	Gas Casualty Set, Veterinary, Chest A, complete containing:		
	9815800	Gas Casualty Set, Veterinary, Empty Chest	Each	1
	9776100	Insert, plywood, No. 2	Each	1

	Med. Dept. Item No.	Item	Unit	Quantity
	9773700	Cover, canvas, dental pack chests	Each	1
	1372200	Potassium permanganate, 5 lb.	Can	1
	7459000	Brush scrub	Each	5
	9105300	Calcium hypochlorite, 3¾ lb.	Can	4
	9903000	Apron, impermeable	Each	1
	9926305	Gloves, impermeable, size 12	Pair	1
	9926310	Gloves, impermeable, size 11½	Pair	1
	9926315	Gloves, impermeable, size 11	Pair	3
	9926320	Gloves, impermeable, size 10½	Pair	1
8.	9815700	Gas Casualty Set, Veterinary, Chest B complete, containing:		
	9815800	Gas Casualty Set, Veterinary, empty chest	Each	1
	9776100	Insert, plywood, No. 2	Each	1
	9773700	Cover, canvas, dental pack chests	Each	1
	1011000	Acid, boric, 1 lb.	Can	1
	1108500	Butyn sulfate, 10 hypo tablets	Tube	2
	1161500	Cupric sulfate, 1 lb.	Bottle	1
	1213500	Gentian violet, 1 lb.	Bottle	1
	1415000	Sodium bicarbonate, 1 lb.	Can	2
	1463500	Sulfanilamide, 1 lb.	Bottle	4
	5597000	Syringe, water	Each	5
	7459000	Brush, scrub	Each	5
	7493000	Soap, white, floating, 6 oz.	Bar	10
	9109525	Eye solution, BAL, ½ oz.	Pkg.	6
	9903000	Apron, impermeable	Each	1
	9914000	Bucket, canvas, collapsible	Each	6
	9926310	Gloves, impermeable, size 11½	Pair	2
	9926315	Gloves, impermeable, size 11	Pair	2
9.	9364000	Oxygen therapy apparatus, closed circuit, Boothby-Lovelace.		
10.	9364200	Oxygen therapy outfit, 20 dual outlet, with hose line assembly, complete.		

APPENDIX IV

CARE OF CONTAMINATED CLOTHING AND EQUIPMENT AT MEDICAL INSTALLATIONS

1. Introduction

In the event of gas warfare, due care must be exercised at Medical Department installations to prevent injury to patients and medical attendants from clothing, blankets, or other equipment which has become contaminated with blister gases. Proper steps must also be taken to obtain timely replacement of items made unusable by contamination, and to insure the salvage and decontamination of such equipment.

2. Removal of Contaminated Clothing and Equipment

a. Clothing and equipment contaminated with a blister gas should be removed from the casualty at the earliest practicable moment, with due regard for the general condition of the patient.

b. Casualties should not be evacuated from Medical Department installations in clothing or blankets known to be contaminated with a blister gas; to do so may result in severe skin burns by contact with the blister gas and in burns of the eyes and respiratory tract from vapors which accumulate in confined spaces such as ambulances or small rooms.

3. Disposition of Contaminated Clothing and Blankets

An area out of doors at a safe distance from the medical installation (preferably at least 100 yards downwind) should be designated as a clothing dump, and contaminated blankets and clothing (except impermeable aprons and rubber gloves) should be transferred to this dump as conditions permit. The dump should be clearly marked "Danger, Gas."

4. Notification of Salvage Officer

The responsible Medical Department officer should notify (by field message or otherwise) the most available salvage officer in his unit area, advising him of the existence of the dump of contaminated clothing and blankets, its exact location, and approximate size.

5. Replacement of Contaminated Blankets

a. To prevent the supply of blankets becoming exhausted, it will be necessary that those lost by contamination be replaced.

b. An informal check on the number of contaminated blankets sent to the clothing dump should be kept, in order that the approximate number or replacements required may be known.

c. If conditions permit, replacements may be obtained by requisition through the normal channels of medical supply (for example, regimental medical supply officer) If the time factor or tactical situation does not permit replacement through normal channels of supply, replacement may be requested from the nearest source of supply with which the unit has contact (for example, collecting company).

d. Succeeding echelons in the chain of combat medical supply should request replacement of blankets promptly, as their supplies are displaced forward. This should operate as far to the rear as the medical depot for the area.

e. Since salvaged contaminated blankets will normally be turned over to quartermaster depots following decontamination, the medical depot should requisition the necessary replacements from the quartermaster depot serving the area.

6. Apron Protective Impermeable (Medical Department Item No. 9903000)

a. The apron, protective, impermeable (Medical Department item No. 9903000) is intended for use by personnel of Medical Department field installations while treating and handling blister gas contaminated casualties. The apron is always worn in conjunction with complete permeable protective clothing (par. 114*b*, FM 21–40) and impermeable protective gloves (rubber) (Medical Department item No. 9926305–20). The gas mask is also necessary as a part of the complete protective outfit.

b. Litter bearers moving into dangerously contaminated areas should don the complete outfit described above before entering such areas. Aid station attendants and others should don the complete outfit prior to handling or treating contaminated patients and the apron should not be removed until the danger of contamination has been removed. If treatment of patients is hampered by the use of the impermeable gloves, such gloves may be removed with comparative safety after removal of all of the patient's heavily contaminated clothing, and the treatment continued wearing protective gloves (cotton). Contaminated aprons may be worn with safety for many hours in conjunction with permeable protective clothing. However, aprons should be decontaminated after each

day of wear, as prolonged contact with the liquid blister gases may have a deleterious effect on the coated fabric. The complete outfit should also be worn while decontaminating litters, ambulances, and other equipment which may have been contaminated in transporting casualties.

c. Before donning the apron, the adjustment of leg, waist, neck, and sleeve closures of the permeable protective clothing are inspected to determine if a protective gas seal is secured and the protective gloves (cotton) are pulled on with gauntlet drawn well up over the sleeve of the shirt. With the neck strap of the apron buttoned, the head is thrust through the opening made by the neck strap and the apron; the left arm is inserted in the respective sleeve, and then the right arm and the tie straps and neck straps are adjusted to obtain a comfortable fit. The gas mask carrier is worn over the apron. Immediately prior to moving into a contaminated area or handling contaminated patients, the gas mask is donned and adjusted. The collar of the shirt is turned up, and the hood, having been previously buttoned to the back of the shirt, is adjusted over the mask. Impermeable gloves are put on prior to handling contaminated patients or material.

d. In removing the apron, the procedure is as follows: After removal of the impermeable gloves, the neck strap is unbuttoned with the left hand and the two carrier straps released so that the canister and carrier hang suspended. The tie straps are released and the right arm removed from the sleeve by inserting the gloved forefinger of the left hand under the elastic cuff of the other sleeve and pulling. This procedure is repeated using the right hand in removing the left sleeve. The apron now falls freely from the body. Care should be exercised in the removal of the apron so that contaminated surfaces of the apron are not permitted to come into contact with the clothing of the wearer or other individuals. Decontamination procedure should be applied as soon as practicable to contaminated articles of clothing and equipment.

7. Disposition of Contaminated Gloves and Aprons

a. It will not ordinarily be possible for aid stations to decontaminate aprons (Medical Department item No. 9903000) and rubber gloves (Medical Department item No. 9926315) during combat operations. Hence gloves and aprons of aid stations which become contaminated during combat should be placed in a gas resistant sack and sent by the most available means to the collecting company with which they are in contact, to be exchanged for fresh aprons and gloves.

b. The collecting company when operating under combat conditions will send contaminated gloves and aprons which are received

from aid stations, plus those which become contaminated at the collecting station, by the most available means to the supply officer for the medical battalion (or regiment, etc.) for decontamination and exchange for fresh supplies.

c. Decontamination of impermeable gloves and aprons for the attached medical troops of the division and for the medical battalion will ordinarily be accomplished by the headquarters section of the medical battalion.

d. Other medical units are responsible for decontaminating their own impermeable aprons and gloves.

8. Replacement of Contaminated Gloves and Aprons

a. Upon the receipt of contaminated aprons and gloves from aid stations, the collecting company will make automatic replacements in kind to the installation from which the items were received by the most expeditious means available.

b. Upon the receipt of contaminated aprons and gloves, the headquarters section of the medical battalion will make an automatic replacement in kind, to the installation from which the contaminated items were received, by the most expeditious means available.

9. Decontamination of Blankets and Permeable Protective Clothing

Contaminated blankets and permeable protective clothing removed from casualties are removed from the clothing dump by direction of the salvage officer. Decontamination of the blankets and protective clothing is then performed by Quartermaster Corps laundry units. Emergency methods of decontaminating blankets and protective clothing are described in TM 3–220.

10. Decontamination of Aprons

Impermeable aprons (Medical Department item No. 9903000) may be decontaminated by one of the following methods:

a. METHOD I. The apron is immersed in water at a temperature just below boiling for a period of 3 hours. It is then dried in air and returned to service.

b. METHOD II. If contamination is light or caused by vapor, the materials may be aired in the sun or wind for several days.

11. Decontamination of Impermeable Rubber Gloves

The decontamination of impermeable rubber gloves must be done carefully to prevent severe chemical burns when subsequently using

them.* The same two methods described in paragraph 10 *a* and *b* may be used for the decontamination of the gloves with the exception that in Method I the gloves are immersed for only *2* hours.

12. Decontamination of Gas Masks, Web, Canvas, and Leather Equipment

a. Emergency decontamination of gas masks, web, canvas, and leather equipment is accomplished by the use of protective ointment. All visible liquid contamination is first wiped off with rags, after which ointment is applied to the contaminated areas and allowed to remain for 15 minutes. The surfaces are then wiped clean with rags. To be most effective, the ointment should be applied within 3 minutes after contamination. Generally, it is not practicable to decontaminate more than 2 square feet of surface by this method. *Caution:* Do not use protective ointment on the lenses of gas mask because it etches them severely. Eyepieces will be decontaminated so far as possible by rubbing them with a cloth or absorbent paper.

b. Gas masks, if lightly contaminated by vapor or droplets, should be removed from their carriers and aired in the sun and wind at every opportunity. Long exposure to heavy vapor concentrations and heavy liquid contamination will require immersion of the mask in plain water maintained just below the boiling point for 3 hours. DANC should not be used to decontaminate the rubber.

c. Gas mask carriers, first-aid pouches, and other web and canvas equipment may be decontaminated by soaking in water, to which 2 ounces of sodium carbonate (washing soda) per 10 gallons of water have been added, for 1 hour at a temperature just below the boiling point. The items are then hung up to dry and returned to service.

d. Shoes, straps, and other leather equipment may be decontaminated by soaking in water heated to a temperature of about 122° to 131°F. (about as hot as the hand can stand), for 4 to 6 hours, then dried in air without excess heat, treated with Impregnite shoe M1, and returned to service. DANC is suitable for use on leather (TM 3–220).

13. Care of Litters

a. PROTECTION. Emergency protection of litters may be accomplished by covering the litter with blister gas resistant materials such as the Cover, Protective, Individual or the Sack, Gas Resistant.

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* In immersing the gloves, care must be taken that the gloves are filled with the solution, and that they are kept below the surface.

b. DECONTAMINATION OF LITTERS. (1) If possible, litters should be disassembled and components decontaminated as follows:

(*a*) *Canvas.* Litter canvas may be decontaminated by immersion in boiling water for 30 to 60 minutes. If available, 2 ounces of washing soda (sodium carbonate) to each 10 gallons of water is recommended. An alternative decontamination procedure is to spray canvas with DANC on both sides repeating two or three times and allowing each application of DANC to dry. Subsequent washing with soap and water is advisable.

(*b*) *Wood.* A 30 percent aqueous slurry of Bleach Powder (Chemical Warfare Issue) is applied and allowed to react for 6 to 24 hours. Applications are repeated if necessary; the wood is then swabbed dry and allowed to aerate at elevated temperatures if possible.

(*c*) *Metal, (unpainted).* Decontamination is accomplished by swabbing or spraying with DANC or available solvents (gasoline, kerosene, etc.) then washing with soap and water and finally drying with rags and aerating several hours.

(2) If the litter cannot be disassembled or conditions do not permit disassembly, the litter should be sprayed with DANC several times, allowing each application to dry; visible liquid contamination should be rubbed off and the litter should be allowed to aerate as long as conditions permit.

APPENDIX V

TREATMENT OF BURNS

1. General

Burns, as discussed in this appendix, include all cases with damage of the skin and underlying tissues due to heat, chemicals or electricity.

2. Fundamentals of Treatment

a. The prevention and treatment of shock.
b. The prevention and control of infection.
c. The relief of pain.
d. The prevention of contracture and scarring by proper splinting and early skin grafting.

3. Treatment

a. GENERAL. (1) Proper steps for the prevention or treatment of shock should be instituted. In the presence of extensive burns, large quantities of plasma (12 units or more) may be required in the first 24 hours. Parenteral fluid replacement other than that attained by means of plasma or whole blood transfusion should be accomplished by means of 5 percent glucose in sterile distilled water. The intravenous administration of sodium chloride solution should be reserved for those burn cases in which mineral depletion occurs, such as that resulting from persistent vomiting. Transfusion of fresh whole blood is often needed as early as the second day to combat the severe anemia which appears following extensive burns; when anemia exists, whole blood transfusion is particularly indicated as a preliminary to skin grafting.

(2) When indicated, specific antibacterial therapy should be instituted. Penicillin is the drug of choice and should be given intramuscularly in doses of 25,000 units every 3 hours as long as indicated. For cases in which sulfadiazine is used, it should be given orally with an initial dose of 4 grams (grains 60). Subsequent doses of sulfadiazine should be given only under the direction of a medical officer. Great care must be exercised in the use of sulfonimides in burned patients because of the danger of kidney damage. The presence of renal damage due to the burn and extensive loss

of fluid from the burned surfaces with resultant decrease in urinary output increase the danger of renal complications due to sulfonimides. When adequate urinary output (1500 cc of urine per day) is obtained, maintenance doses of sulfadiazine, 1 gram (grains 15) every 4 hours, should be given. Four grams (grains 60) of sodium bicarbonate should be given with the initial dose of sulfadiazine and 2 grams (grains 30) every 4 hours thereafter to keep the urine alkaline.

(3) Prophylaxis against tetanus is indicated in all patients with second and third degree burns. Army personnel who have previously received tetanus toxoid should receive a step-up dose of 1.0 cubic centimeter. Those individuals who have not previously received tetanus toxoid should be given 1500 units of tetanus antitoxin (after careful skin-testing for possible sensitivity to horse serum) immediately and weekly during the period of healing.

(4) Pain should be relieved by adequate doses of morphine. In the presence of pronounced anoxia large doses of morphine are dangerous, and under such circumstances the dose should not exceed ¼ grain (0.016 grams). In the presence of shock, morphine administered subcutaneously may not be absorbed due to the poor circulation. If repeated doses are given, the return of normal circulation may result in complete absorption and morphine toxicity.

b. First-Aid Emergency Treatment of Burned Area. (1) The burned surface will be covered with a liberal amount of sterile petrolatum, or if this is not available boric acid ointment. The area should then be covered with strips of fine mesh gauze (44 mesh gauze bandage is satisfactory). Over this should be placed a thick layer of sterile gauze dressings, such as large or small first aid dressings. Finally a gauze or muslin bandage should be firmly applied over the dressings.

(2) Contamination of the burned surface by organisms from the nose and throat is responsible for many of the severe infections which occasionally develop. Therefore, to minimize contamination from this source, masking should be practiced by surgeons and assistants.

(3) The prompt administration of plasma is of utmost importance in the emergency treatment of burns.

c. Treatment of Burned Area When Patient Arrives Where Hospital Facilities Exist. The burned areas will be treated as follows, using standard operating room technique with patients and attendants fully masked.

(1) In cases in which the surface appears clean no further preparation is necessary.

(2) Where the burned surface is grossly soiled, the areas are to be cleaned *gently* using cotton and neutral soap and water. The

area will then be rinsed with sterile isotonic saline. Green soap and brushes will not be used.

In debridement, loose shreds of epidermis will be removed. Small intact blisters will be left undisturbed. Large blisters may be evacuated by means of sterile needle and syringe. General anaesthesia should be avoided and morphine used to alleviate pain during cleansing, debridement and application dressings.

(3) (*a*) Tannic acid and all other tanning agents or escharotics will not be used. The burned area will be covered with sterile petrolatum or boric acid ointment if the former is not available. Strips of fine mesh gauze should then be applied, followed by a smooth, thick layer of sterile dressings, absorbent cotton, cotton waste or cellulose. The dressings should be held in place by an even, firmly applied bandage of stockinette or some form of elastic bandage.

(*b*) The dressings should extend well beyond the burned area, and in cases involving the extremities it should include all of the extremity distal to the burn. Adjacent burned surfaces on fingers and toes should be separated by vaseline gauze and thin dressings prior to the application of pressure dressings.

(*c*) It is of utmost importance to observe the state of the circulation in a burned extremity with this type of dressing, particularly during the first day when edema is developing. If undue pain, coldness, or cyanosis appear, the bandage should be split.

(*d*) The use of infrequent dressings in the treatment of burns is especially desirable. For this reason, the initial dressing in a clean case should not be disturbed for the first 10 to 12 days. Immobilization of the burned part by splinting should be carried out where feasible.

(*e*) Thereafter slough will begin to separate and may be removed surgically when possible.

(4) (*a*) Early epithelization is one of the most important factors in preventing contractures and in obtaining an optimal functional and cosmetic result. For this reason skin should be grafted onto the granulating surfaces as early as possible. If infection is present, it should be controlled preparatory to skin grafting by the administration of penicillin in doses of 25,000 units of the sodium salt intramuscularly every 3 hours as long as indicated.

(*b*) Frequent transfusions of fresh whole blood and plasma and a very high protein diet are necessary to maintain nutrition and to promote healing.

APPENDIX VI

DETECTION OF CONTAMINATED WATER AND ITS PURIFICATION

1. General

Contamination of water supplies is to be expected in areas subjected to attack with chemical warfare agents. This contamination may reach harrassing or toxic concentrations and, if undetected, can produce a large number of casualties. The presence of dangerous amounts of chemical warfare agents in water can be determined by special methods of analysis. The purification of contaminated water is difficult and requires chemicals and equipment not regularly issued to troops. Transportation of water may be required. Purification should be resorted to only in extreme emergency.

a. CAUTION. Even when chemical tests fail to detect the presence of chemical warfare agents, water obtained from sources known to be, or suspected of being contaminated must not be consumed in amounts greater than two or three swallows at a time and not more than three canteenfuls during the first 24 hours after contamination. To guard against cumulative effects, this water should not be used for periods exceeding one week.

b. IMPORTANT AGENTS. The vesicants and the systemic poisons, cyanogen chloride and hydrogen cyanide, are the agents most likely to cause casualties when introduced into water. It is considered improbable that toxic concentrations of heavy metals and alkaloids will be encountered.

2. Toxic Limits

The toxic limit for lewisite (L) is 20 ppm (20 mg/1), (10 ppm (10 mg/1) as As_2O_3), provided the water is chlorinated by the standard procedure for bacterial purification and is used for not more than 1 week. Unhydrolized nitrogen mustards (HN) in concentrations of 10 ppm (10 mg/1) have produced vomiting in man when consumed in 200 cc quantities at a time but have not caused actual casualties. In higher concentrations they are extremely toxic. Mustard (H) dissolves slowly in water but may be found floating in tiny globules, as a film on the surface or collected in pools on the bottom. Small droplets when fed with water to rats have produced perforating ulcers in the intestinal tract. The limits

for cyanogen chloride (CK) and cyanide (AC) are 25 ppm (25 mg/1).

3. Reactions with Water

The three vesicants, lewisite, mustard, and nitrogen mustards, all react with water to form hydrochloric acid and the hydrolysis product corresponding to the agent. Lewisite reacts with water practically instantaneously, forming the hydrolysis product lewisite oxide, which is toxic and somewhat vesicant. Mustard (H) reacts with water to form the nontoxic thiodiglycol. A solution containing 100 ppm (100 mg/1) mustard becomes nontoxic at the end of 1 hour. Some types of mustard contain a highly odorous compound which renders the water nonpalatable even after hydrolysis. Nitrogen mustards hydrolyze slowly to a nontoxic product. A solution containing 100 ppm may remain toxic for 4 to 6 days. Cyanogen chloride is soluble in water to the extent of 6 to 7 percent by weight at one atmosphere pressure and 25°C. This compound hydrolyzes slowly in water forming cyanates which readily decompose into harmless products. A concentration of 50 ppm will be hydrolyzed to 25 ppm in about one week. Hydrocyanic acid and many of the cyanide salts are very soluble in water and do not react appreciably with it.

4. Detection

a. Kit, Water testing, screening, for detection of chemical warfare agents. The Medical Department issues a kit (Medical Department item No. 9931000) for simple, rapid field tests of water for dangerous chemical contaminations. These tests ordinarily are performed in the combat zone at the Engineer Corps water supply points. Further tests of water furnished by water supply troops of the Engineer Corps are not required, unless chemical contamination during its transportation from supply points is suspected. In combat it may be impracticable, or impossible, to obtain water from Engineer Corps water supply points. If it becomes necessary to use other water, the unit surgeon will be responsible for determining the potability of water procured for the troops of his unit. Under such circumstances, the kit, water testing, screening (Medical Department item No. 9931000) should be employed by the unit surgeon. Tests should be made of the raw water, prior to chlorination. If this is found to be free of contamination, it may be used *after the usual purification by chlorination to render it safe from bacterial pollution* (ch. 3, FM 8–40).

b. DESCRIPTION OF WATER TESTING KIT. For the sake of simplicity, analytical procedures have been developed to employ dry reagents which are furnished as tablets or pellets of proper size.

Except for warming with the hand in some of the tests, no heat is required. The kit contains equipment for testing 15 samples of water. The reagents and equipment are packed in a pocket-sized container, approximately 5½ by 3¾ by 1¾ inches, divided into 10 compartments. The container is constructed of transparent plastic. The kit contains 2 test tubes, a chlorine demand assembly (QM 11968), a bottle and tube for the detection of arsenicals by a modified Gutzeit method, and 7 vials containing reagents and test papers. The vials are identified by letters printed on the paper liners. Their caps are made of colored plastic matching the color of the paper liners. A test tube brush and pipe cleaner are provided for cleaning the apparatus.

c. PURPOSE. (1) The field kit for testing water is designed as for reconnaissance. It is employed to screen out sources of water so contaminated that they cannot be rendered potable by customary field methods, such as chlorination in the Lyster bag.

(2) Negative tests indicate that the water is suitable for chlorination and may be used by troops, within the limitations.

(3) If any of the tests are positive, the water should not be used until a more complete analysis can be made.

(4) The main purpose of the kit is to detect contamination of raw water. It is not designed for use on treated water as the chemical reactions of water treatment invalidate the interpretations.

d. ANALYTICAL PROCEDURES. A booklet issued with the kit gives specific directions for each test. Nontechnical language is used and the reagents are referred to by the letters on the vials. These directions must be followed exactly. Briefly, the tests involve the following chemical processes:

(1) Arsenicals are converted to arsines through the action of hydrogen, produced by the action of sodium acid sulfate on zinc. The arsine reacts with a sensitized paper to produce a stain. This is sensitive to 5 ppm.

(2) pH is determined by indicator paper.

(3) Mustards are detected by means of the DB3 reagent; 5 ppm (5 mg/l) of unhydrolyzed nitrogen mustard and 15 ppm of unhydrolyzed sulfur mustard can be detected. Cyanogen chloride produces a yellow color with the DB3 reagent.

(4) The chlorine demand or chlorine uptake is determined by means of halazone tablets and an orthotolidine testing assembly. (QM 11968). This test detects the presence of other agents, such as the cyanides, not specifically tested for.

(5) If no evidence of contamination is found, odor and taste can be tried with safety.

e. INTERPRETATIONS.

Test	*Indication of positive results*
Arsenicals	¼-inch stain on test paper.
pH	Below 6 when compared with color standards.
Mustards	Any blue or red color no matter how faint and transitory.
Chlorine Demand	No color in solution or color lighter than that of band in plastic tube.
Taste and Odor	A lacrimating or chlorinous odor, a biting and/or peppery chlorinous taste, any taste or odor of a known war gas.

If one or more of the above tests gives a positive result, the water will be considered contaminated.

f. LIMITATIONS. (1) If the tests are carefully performed, the threat of serious casualties from contamination of the water with known agents will be avoided.

(2) The tests provided by the kit will not screen out traces which are harmless when the water is used for short periods of time. When arsenic is detected, even though the water is passed as safe by the kit (that is, an arsenic content which gives a stain shorter than ¼ inch on the test paper), the water should be used for drinking and cooking purposes not to exceed *1 week,* because of possible cumulative effects.

(3) Water may give a negative test for nitrogen mustards and still give symptoms if consumed in large quantities. Hence the water should not be used without special purification (by Engineer Corps Water Supply Troops) even if the faintest blue color develops in the test for mustards.

(4) The tests provided by the kit are not quantitative, and will therefore not serve as a guide for the purification of field water supplies. More elaborate methods are available to the Division Medical Inspector and the Laboratory, Army. These methods are described in detail in TB MED 37 and changes thereto. The special equipment is Kit, Water Testing, Poisons, Treatment Control, Med. Dept. item No. 9930700.

5. Action Required if Water is Found to be Contaminated by Chemical Agents

Whenever positive tests are obtained with the kit, water testing, screening, the water will be considered contaminated and the following actions taken:

a. The unit commander will be notified that the water source is contaminated and is unfit for drinking purposes.

b. The unit commander will establish the necessary safeguards to prevent troops from drinking the contaminated water.

c. An alternative source of uncontaminated water should be sought and, if found, should be employed.

d. If a source of uncontaminated water cannot be found, consideration should be given to moving to a different location, or to importing purified water to the area.

e. In any event, the contaminated water should not be used by troops until it is purified by the water supply troops of the Engineer Corps.

f. Contamination discovered in otherwise suitable water should be reported as promptly as possible to the headquarters of the division, or other comparable command, so that the matter can be brought to the attention of the division medical inspector and the commanders of Engineer Corps water supply unit for necessary action.

6. Scale for Issue of Water Testing Kits

The Kit, Water Testing, Screening has been added to the contents of the Kit, Treatment Gas Casualty (Med. Dept. item No. 9776700) and therefore is available to battalion medical sections and to medical units so equipped. It is available also on separate issue to Engineer Corps water supply units and to the Medical Inspectors of Divisions and higher echelons. When the contents have become exhausted, the complete kit can be replaced through the usual channels of medical supply.

7. Use of Suspected Water

a. Water suspected of being contaminated but giving negative tests with the Kit, Water Testing, Screening can be used sparingly, after chlorination, for periods not to exceed one week.

b. When suspected water is used, great care should be taken not to stir up material from the bottom as it may contain chemical agents when the water above does not.

8. Procedure in Case of Heavy Contamination

When water is too heavily contaminated to pass the screen kit test, every effort should be made to secure another source or to have pure water supplied from elsewhere. To meet emergencies, Sanitary Corps officers are provided with equipment for making more complete analyses. The methods for treatment are outlined briefly below. Only trained personnel should undertake such procedures.

9. Purification of Contaminated Water

a. Water must be withdrawn from the intermediate levels with minimum disturbance of the surface and no disturbance of the bottom.

b. TREATMENT OF LARGE VOLUMES. (1) The contaminated water is pumped into a canvas reservoir and a quantitative analysis made by a Sanitary Corps officer.

(2) It is then treated with activated carbon (200 mesh) in the following doses:

(*a*) For lewisite, 30 ppm (30 mg/1) carbon for each ppm (mg/1) lewisite.

(*b*) For mustard, 30 ppm (30 mg/1) carbon for each ppm (mg/1) mustard.

(*c*) For nitrogen mustard, 60 ppm (60 mg/1) carbon for each ppm (mg/1) nitrogen mustard.

(3) The carbon and water are mixed for 20 minutes to insure complete absorption of the agent by the carbon.

(4) 175 ppm (175 mg/1) of coagulant is added to the carbon-dosed water, together with sufficient alkali to give optimal coagulation.

(5) After thorough, gentle mixing, the water is allowed to coagulate and clarify by sedimentation for 30 minutes.

(6) The supernatant water is filtered through the portable water purification unit, at normal rate of 10 gpm. or preferably more slowly.

(7) The filtered water must be tested quantitatively to see that it meets the following requirements:

(*a*) Mustards, not more than 2 ppm (2 mg/1).

(*b*) Lewisite (arsenicals), not more than 20 ppm (20 mg/1).

(*c*) PH above 5.

(*d*) Chlorine demand, less than 5.

(*e*) No chemical odor or taste

c. TREATMENT IN LYSTER BAGS. (1) When the portable water purification unit is not available, small volumes can be purified by using two Lyster bags.

(2) If testing equipment is available to identify the contaminating agents and determine their concentrations, add activated carbon in the dosages given in *b*(2) above to the water in one Lyster bag. If the identities and concentrations of contaminants are unknown, add 2 pounds of activated carbon.

(3) Stir for 20 minutes.

(4) Add 1 ounce of alum and sufficient alkali to give optimal coagulation. These chemicals should be dissolved separately in small volumes of water prior to their addition to the Lyster bag.

(5) After thorough, gentle mixing, allow to coagulate and clarify by sedimentation for 30 minutes.

(6) Siphon the supernatant water to another Lyster bag (preferably through a filter).

(7) After testing to insure that the requirements of *b* (7) above are met the water in the second Lyster bag must be chlorinated.

10. Chlorination of Contaminated Water

Chlorine reacts with some of the chemical agents making it difficult to remove them by the activated carbon and alum treatment. Therefore, chlorination should be carried out only *after filtration* through the portable purification unit, and the chlorine feed-line must be connected to the effluent pipe from the filter. In the case of treatment in the Lyster bag, chlorine is added in the *secona* Lyster bag. When contamination is suspected, no chlorinating compounds should be added until the water has been clarified.

APPENDIX VII

CHEMICAL AGENT CONTAMINATION OF FOOD, FORAGE, AND GRAIN

1. General

a. Contamination of foodstuffs, by chemical warfare agents may occur from contact with vapor, sprays or splashes of liquid, or solid chemicals. Unprotected food, forage, and grain supplies may be so contaminated that their consumption produce gastrointestinal irritation or systemic poisoning. The vesicants and arsenicals are the most dangerous.

b. Food supplies in storage are not likely to be seriously contaminated if reasonable precautions are taken to protect them against chemical attack. For this reason, large supplies of food should not be condemned en masse simply because they have been exposed to the possibility of chemical contamination. A prompt and careful survey of the supplies may reveal that only a few items have been so seriously contaminated as to require special treatment. Prompt segregation of the heavily contaminated portions will prevent or minimize contamination of the remainder. Generally, foods not especially packed in protective packages constitute the major difficulty. The availability of fresh supplies and available means of decontamination will dictate whether or not reclamation of these contaminated items is worth while. The Quartermaster Department's present methods of packing foods for oversea shipment greatly minimizes the danger of contamination.

2. Susceptibility to Contamination

The vesicants and chlorpicrin are readily soluble in fats. They will be absorbed by foods of high fat content, and because of diffusion throughout the material, it may be impossible to remove them. Coagulation of protein by agents such as the arsenical vesicants which are acidic or acid-forming may limit diffusion of the agent in high protein foods. Hydrolysis of acid-forming gases in foods of high water content causes decomposition products which render the food unpalatable. Foods of low water and fat content will be relatively less easily contaminated by chemical agents and less difficult to decontaminate. Mustard gas used by the enemy may contain considerable quantities of an arsenical agent, and this fact should be kept in mind.

3. Protection Afforded by Wrapping Materials

In determining the disposition of packaged and stored supplies which have been contaminated, consideration must be given to the nature of the contaminant as well as to the type of foodstuff and the security afforded by the packaging material. Some of these factors are outlined as follows:

a. Airtight bottles and sealed tins give complete protection against vapor and liquid.

b. Wooden barrels, well sealed for the exclusion of air, give complete protection against vapor and moderate amounts of liquid.

c. Wooden boxes, not sealed for the exclusion of air, give little protection against vapor or liquid.

d. Waxed paper boxes, well sealed for the exclusion of air, give good protection against vapor and fair protection against liquid.

e. Paper wrapping gives poor protection against vapor and very little against liquid.

f. Foil and cellophane wrappings, sealed for the exclusion of air, give good protection against vapor and liquid.

g. Ordinary textiles in a single layer packaging give practically no protection against vapor and liquid.

h. Coverings of sod and earth give good protection against vapor and liquid.

i. Open shelters give protection against liquid sprays and splashes. Closed buildings give protection against both vapors and liquids.

j. Generally, double layers greatly increase the protective efficiency of packaging materials.

k. Special Quartermaster rations such as D, K, TEN-IN-ONE, Mountain, and Parachute Emergency are so packaged as to protect the enclosed foods for many hours even when the outside of the package is heavily contaminated with the liquid agent.

4. Storage of Food Supplies

When it is necessary to store bulk food supplies which are poorly protected by packaging, measures should be instituted to make the storage space as gasproof as possible. The most vulnerable food should be placed in the least exposed positions, keeping in mind the fact that the vapors of chemical warfare agents are heavier than air and tend to accumulate in low places. In the field, tarpaulins covering food supplies give fairly good protection against vapor and liquid agents.

5. Reclamation of Contaminated Supplies

a. GENERAL. Food supplies which have become contaminated should be handled only by those trained in decontamination methods

and equipped with protective clothing and gas masks. Before undertaking any decontamination procedures, a careful survey should be made to determine the extent of contamination. From information gained on this survey, the exposed items should be divided into three groups for separate treatment as described below.

b. GROUP I. This group will consist of packaged items which have been exposed only to the vapors of the agent. A consideration of the factors outlined in paragraph 3 above will serve as a basis for the evaluation of the seriousness of contamination. Generally, the items in this group will be safe to issue to troops after a brief period of airing to remove clinging vapors.

c. GROUP II. This group will consist of packaged items the outside of which have been contaminated with the liquid agent. Attempts to decontaminate porous packaging materials such as cardboard or wood are likely to be unsuccessful and may actually result in spreading the contamination. The correct procedure in handling such items is to strip off the outer contaminated wrapping and examine the inner layer to see if penetration of the agent has occurred. If it has, continue stripping off layers until an uncontaminated layer is reached. Items packed by the Quartermaster Department are usually packaged in boxes within boxes so such a procedure is feasible. When an inner uncontaminated package is reached, it should be placed in Group I. If the agent has penetrated to the food itself, place in Group III. Canned goods may be decontaminated by any of the usual chemical methods such as bleach slurry or decontaminating solution noncorrosive (Chemical Warfare Service Issue, DANC) followed by washing in water.

d. GROUP III. This group will consist of unpackaged or poorly packaged items which have been exposed to the gaseous or liquid agent. The general decontamination procedure to be followed in order is: trimming of surface fat and grossly contaminated areas; washing with water or 2 percent sodium bicarbonate solution; boiling in water. Boiling in water may be eliminated when the contamination has been only with the vapors of the lung irritants or lacrimators. When such an exposure has been light, aeration for a short time may be used for decontamination. Frying, roasting, or broiling will not remove traces of vesicants from meats. In general, salvage of foods heavily contaminated with droplets of the vesicants, especially the arsenical vesicants, is not practicable. More detailed directions are given below.

e. LUNG IRRITANTS. This group of agents offers relatively little danger to food products. With the exception of chlorpicrin, these decompose rapidly upon contact with the water in foods, to form comparatively harmless compounds which may alter the flavor. Decontamination can be accomplished by washing, supplemented,

where possible, by aeration. Chlorpicrin is slightly soluble in water, and is soluble in fat and most organic solvents. Its removal from foods of low water and fat content can be accomplished by aeration.

f. LACRIMATORS AND IRRITANT SMOKES. (1) Large stocks of supplies, when protected by covers or packages, probably cannot be contaminated with a sufficient quantity of the lacrimators or irritant smokes to warrant their destruction. These agents are not easily decomposed by hydrolysis and it would be difficult to reclaim foods *heavily* contaminated by them.

(2) Dry provisions contaminated by lacrimators can be decontaminated by aeration.

g. VESICANTS. (1) When contaminated with *liquid* mustard or a *liquid* nitrogen mustard, foods of high water or fat content are unfit for consumption and reclamation is not practical. When foods have been exposed to vesicant vapor, they can be reclaimed by washing with soda solutions and rinsing with clear water, intensive cooking, or in the case of dry provisions, by 24 to 48 hours' aeration. Lean meat can be reclaimed by boiling in water for ½ hour or more, or in the case of the nitrogen mustards, with a 2 percent solution of baking soda. The water must be discarded after boiling.

(2) Lewisite, ethyldichlorarsine, and phenyldichlorarsine readily hydrolyze to poisonous arsenical oxides. Foods contaminated with these agents cannot be reclaimed.

h. SCREENING SMOKES. (1) HC, FM, FS, and WP smokes are nontoxic. They may alter the taste of foods by acids produced on contact with moisture, but do no damage otherwise.

(2) Liquid FM (titanium tetrachloride) can be washed from foods. Liquid FS (sulfur trioxide-chlorosulfonic acid solution) is highly corrosive and forms strong acids on contact with moisture. It may render unfit for use foods which cannot be washed readily. After trimming, washing, or cooking, if the food does not taste too acid, it is safe to use.

(3) Unburned particles of white phosphorus are poisonous and must be removed from foods. Fats and oils may dissolve poisonous amounts of the agent and should be discarded.

i. OTHER AGENTS. Carbon monoxide, arsine, and hydrocyanic acid will have little effect upon food supplies. Hydrocyanic acid is water soluble and foods with high water content may become unfit for consumption after exposure to high concentrations of that agent. The effect of cyanogen chloride on foods is not known. As a precaution, foods exposed to the vapors of this material should be considered toxic.

j. MEAT FROM GASSED ANIMALS. It may be necessary to use animals for food after they have been exposed to liquid splashes of

chemical warfare agents. Economics may justify the early slaughter of exposed animals *before the effect of such exposure is shown.* If such animals are slaughtered in the preliminary stages of poisoning and all tissues exposed to the gas (lungs, local areas) are discarded, there is no objection to the consumption of the meat, provided the animal passes an otherwise satisfactory meat inspection. This is true even of animals poisoned by arsenical agents, since the edible tissue will contain amounts of arsenic too small to be toxic. Organs such as the liver, brain, heart, kidney, and lungs will contain relatively more arsenic than the musculature, and should be discarded. The meat should be well cooked.

k. Forage and grain exposed to vapor contamination by chemical agents can be decontaminated by aeration. Supplies so treated, especially if mixed with larger amounts of uncontaminated supplies, produce no ill effects when fed to animals. Forage, which is heavily contaminated by liquid vesicants, especially arsenicals, should not be used.

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